(Established 1832.)
AMERICAN ENGINEER AND RAILROAD JOURNAL.

RAILWAY SHOPS.

BY R. H. SOULE.

IV.

THE MACHINE SHOP.

The machine shop floor area per erecting shop stall, for a large number of shops, both repair and construction, has been given in Table 7, an analysis of which discloses the fact that although there are wide limits of practice, there is nevertheless evidence that a liberal provision of machine shop floor space very favorably affects erecting shop output. The exact amount of machine shop floor space which it is best to provide for a given installation is an economic problem which involves consideration of the questions of interest on capital, land values, etc. The design of a machine shop not being limited to a few types, but in fact admitting of great variations, it is not practicable to give one or more typical cross sections, as was done in the case of the erecting shop, but certain essential features may be considered and discussed.

Good practice requires the use of firm floors. Where laid on earth a stratum of concrete should be interposed. This need not necessarily be the usual cement sand and broken stone mixture, but rather some cheaper substitute which may make use of locomotive front end cinders flushed with tar or asphaltum, the whole covered by a layer of planking and a thinner top dressing which may be easily renewed in spots. Such a floor construction makes foundations quite unnecessary, except for a few of the heavier tools; these and other tools which have individual electric drives are relieved from belt pull tending to lift them from or shift them on their foundations, while lighter shaft driven tools may be fastened down with lag screws or hook bolts. In a two-story structure the upper floor should be of heavy planking, with top dressing as before.

The loss of time resulting from the use of two-story structures for machine shop purposes, though indeterminate, is nevertheless actual and inevitable, and that form of construction should not be resorted to unless for the reason that land is obtainable only at a prohibitive price. In addition to the loss of time resulting from the transportation of men and materials, there is a loss of floor space, repeated on each floor, where stairways and elevators are provided, and the loss which comes from the impaired lighting of the lower story. Besides this it is often necessary to introduce columns to support the second floor and these are an obstruction and interfere with the grouping of tools and the movement of men and materials on the first floor.

In the machine shop department of the average locomotive repair shop it is seldom the case that tools occupying more than one-third of the total floor space can be served to best advantage by an overhead traveling crane, and it so happens that these are the tools which are best adapted to the individual electric drive and do not require overhead shafting. If driving wheels are stored inside the building it may be necessary to increase the amount of floor space covered. The balance of the tools can be better served by local and individual cranes and hoists, which also permit of the placing of shafting and motors overhead. Every machine shop should be so designed that all shafting may be hung either from the roof trusses, from walls, or from structural columns, as floor stands for shafting support are very much in the way and occupy space which is valuable for other and more legitimate purposes. The walking crane is not as well known in this country as in England, but as modernized and adapted to be electrically driven is a very satisfactory appliance. It takes up a minimum of floor space and head room, has a deck on which material may be laid, does not require highly skilled labor to operate, and leaves the operator free to assist in adjusting slings, etc., which cannot be done by traveling crane operators.

The traveling crane equipment and the head-room of several machine shops are given in Table 8. A capacity of ten tons appears to be sufficient for the traveling crane. Its heaviest load would probably be a pair of cylinders bolted together, which, in the case of some compound engines, weigh upwards of eight tons. When the head-room figures are examined in connection with the designs from which they were taken it is found that certain apparently excessive dimensions are accounted for by structural considerations. Eliminating these it would appear that in one story machine shop structures 25 ft. is sufficient head-room in a crane bay (of moderate width), while 20 ft. is liberal in a bay where cranes are not used. When these limits are exceeded it is for structural reasons (as stated before) or, in the case of very broad shops, to secure better lighting. Where there is a second story in a bay where cranes are not used the head-rooms on the first and second floors might be taken as approximating 18 and 15 ft. respectively.

TABLE 8—TRAVELING CRANE EQUIPMENT AND HEAD-ROOM IN SEVERAL TYPICAL MACHINE SHOPS.

Place.	Railroad.	Year Built.	Traveling Crane Equipment.	Head-room (Approximate) Where Cranes Are Used. Ft. Ins.	Where Cranes Are Not Used. 1st Floor. Ft. Ins.	2d Floor. Ft. Ins.
Depew, N. Y.	New York Central	1893	.....	.....	22—0	.....
Concord, N. H.	Boston & Maine	1897	.....	.....	18—0	.....
Chicago, Ill. (Annex)	Chicago & Northwestern	1900	.....	.....	18—0	13—0
Oelwein, Iowa	Chicago Great Western	1900	1 15-ton	33—6	17—9	14—7
Fond du Lac, Wis.	Wisconsin Central	1900	2 5-ton	22—9	22—9	.....
Hannibal, Mo.	Hannibal & St. Joseph	1901	.....	.....	16—4	16—4
Dubois, Pa.	Buffalo, Rochester & Pittsburg	1901	.....	.....	20—0	.....
Elizabethport, N. J.	Central Railroad of New Jersey	1902	1 10-ton 1 5-ton	30—9	20—3	.....
Reading, Pa.	Philadelphia & Reading	1902	2 10-ton	33—5	Cranes	throughout
Baring Cross, Ark.	Missouri Pacific	1902	.....	.....	21—0	.....
Omaha, Neb.	Union Pacific	1902	2 10-ton	40—0	19—0	17—6
Pocatello, Idaho	Oregon Short Line	1902	1 10-ton	39—0	19—0	17—6
Jackson, Mich.	Michigan Central	1903	1 7½-ton	.....	18—6	.....
Topeka, Kan.	Atchison, Topeka & Santa Fé	1903	2 5-ton	20—0	15—0	12—0
Oak Grove, Pa.	New York Central	1903	.....	.....	18—0	.....
Montreal, Can.	Canadian Pacific	1903	2 10-ton	32—9	19—0	17—9
McKees Rocks, Pa.	Pittsburg & Lake Erie	1903	.....	25—9	Cranes	throughout

The structural designs and specifications of a building to be used as a machine shop should require that the members, whether roof trusses or floor girders, from which shafting, hoists, etc., are to be hung, should be built truly horizontal, without camber, and should expose below broad flat surfaces with flanges, over the edges of which hook bolts may be attached. This construction permits the attachment of supports for shafting, hoists, etc., without drilling holes in metallic members, and facilitates slight changes of location, which often become necessary.

The selection of tools for the machine shop is a matter of critical importance, especially under existing conditions, when tools are being redesigned and their output modified by the use of new cutting steels and the electric drive. The safest way in the case of a new and large plant would be to organize a special commission to deal with the question and prepare the list. Two or three men who had actual charge in large shops

and say two representatives of the tool manufacturers could, by comparing the tool lists of existing plants, jointly determine the requirements of the plant under consideration. It is not simply a question of the design and specification of each individual tool, but also the question of how many tools of each kind are needed in order that work on the several parts of the locomotive may progress at such a rate that the finished work will be ready a little in advance of the schedule time when it may be required.

The location and grouping of tools may be governed by a few general principles. The heavier tools (say those requiring 5 h. p. or over to drive) should be located under a traveling crane. Tools working exclusively on castings should be placed near the point at which castings are received into the shop. Those working exclusively on forgings should be placed near the receiving point for forgings. Different tools engaged on the various processes of producing one finished article should be grouped together. Sufficient floor space adjacent to each tool should be reserved for the storage of a reasonable quantity of raw material and finished product. Passageways for the movement of men and material must be reserved.

In applying these principles to a given plant it will at once be found that their claims are often conflicting, and that a judicious compromise must be effected. Such necessary compromise should never fail, however, to provide direct passageways for the movement of material along those lines on which the work naturally progresses. In a locomotive shop, whether for construction or repairs, a great advantage is gained if driving wheels can be handled entirely by the same cranes that cover the erecting stalls; otherwise the wheels must be rolled from one crane bay to another, which seems easy, but is actually a laborious operation, and open to many inconveniences and objections, owing to the excess of counterbalance. Custom has placed the heavier tools on that side of the machine shop nearest to the erecting shop; this practice has undoubtedly been copied from locomotive construction shops, but can hardly be justified for repair shops, where the aggregate movement of high priced labor between locomotives and light tools greatly exceeds the aggregate movement between locomotives and the heavy tools, this latter being done, moreover, by cheap labor.

Although a layout plan showing tool locations should always be made in advance, yet it should never be regarded as final, and the person having charge of the actual placing of the tools in the shop should be empowered to make considerable variations in the location of individual tools, provided the general scheme of grouping is adhered to. After all the tools have been actually located a final layout plan may be made for purposes of record. In this connection it should be stated that in general it is cheaper in the end to duplicate lighter tools, say up to a value of $500 each, rather than to be compelled to transport material long distances from some other tool by which it has been partly finished. The duplication of such light tools in different places is simply a recognition of one of the principles mentioned above.

The best method of driving tools is undoubtedly the electric drive applied individually to the heavier tools, to isolated tools, to those lighter tools which require the use of variable speed, and applied collectively to groups of such lighter tools as may be economically run at approximately constant speeds. Under present conditions direct current best meets all the conditions, but when the induction motor can be made to give a variable speed then the alternating current will undoubtedly be the primary current, which may be transformed into direct current for the few remaining applications where the direct current will give better results. Every electrically driven shop should have motor speed control attachments to certain motors, but it is not possible to here discuss the relative merits of rheostatic control, field control, or multi-voltage control, which may be combined and modified in various ways. Data on the power required to drive individual tools has been accumulating so rapidly since the electric drive was introduced that the rating of tools has become comparatively easy; similarly, enough completed plants have been in operation under close observation to enable the designer of new plants to assume a load factor for group drives which will insure an abundance of power at the tools on the one hand and on the other will keep the size of the motor down to an economical limit.

A well appointed tool room should be a feature of every machine shop, but its scope and design admit of such wide variation that no standard proportions can be established. The principal requisites are that its location should be central and its equipment complete and liberal.

(To be Continued.)

AMERICAN ENGINEER TESTS.

Locomotive Draft Appliances.

REPORT BY PROF. W. F. M. GOSS.

XVI.

SECTION VI., ARTICLE 40. (Continued.)

(Continued from Page 155.)

If, now, an expression can be found which can be substituted for the coefficient of D and which will represent the height of stack in inches in each of the four equations, it will be possible to write a single equation in the place of four. That this may be more readily accomplished, the values representing best diameters with which we have been dealing were so chosen that while doing no violence to the experimental data, they will, when plotted in terms of height-of-stack, and diameter-of-stack, fall upon the same straight line, all as shown by Fig. 100. This fact makes it possible to write in simple form a general equation expressing the relation thus defined. Thus, by Fig. 100, it is apparent that when the stack height is zero, the diameter is equal to something over 13 ins. (more exactly 13.28) and the slope of the line connecting the several experimental points is such that with each inch height of stack, the diameter increases .00123 in. × 54. If, as in the previous case, we may convert the expression, which as it stands applys only to the Purdue locomotive, into a general expression, by substituting D for the diameter of boiler (54 ins.) we may write as the coefficient of D, in the four preceding equations,

$$(.246 + .00123\ H)$$

in which H is the height of the stack in inches.

As proof that this expression satisfies the conditions of the four equations preceding, we may substitute in succession the several values of H for which the preceding equations apply, and obtain in each case a result which will be identical with the coefficient of D which is there written. Thus:

In the preceding equation for stacks 26½ ins. high, the coefficient of D is .28. Making the H which appears in the proposed coefficient equal to 26½, we have:

$$(.246 + .00123\ H) = .246 + .00123 \times 26.5 = .2785.$$

Similarly, for stacks 36½ ins., the coefficient of D is 29; for stacks 45½ ins. the coefficient is .30; and for stacks 56½ ins. the coefficient is .31, respectively. The general expression for each of these coefficients is:

$$(.246 + .00123\ H) = .246 + .00123 \times 36.5 = .2908$$
$$(.246 + .00123\ H) = .246 + .00123 \times 46.5 = .3031$$
$$(.246 + .00123\ H) = .246 + .00123 \times 56.5 = .3154$$

We may, therefore, write for any straight stack when the exhaust nozzle is on the center line of the boiler,

$$d = (.246 + .00123\ H)\ D$$

d being the diameter of the stack in inches when the exhaust nozzle is on the center line of boiler, H the height of the stack in inches, and D the diameter of the front end of the boiler in inches. A liberal interpretation of this equation is to the effect that the diameter of a straight stack should be approximately one-fourth the diameter of the front-end plus .0012 inch for each inch in height. Modification in the form

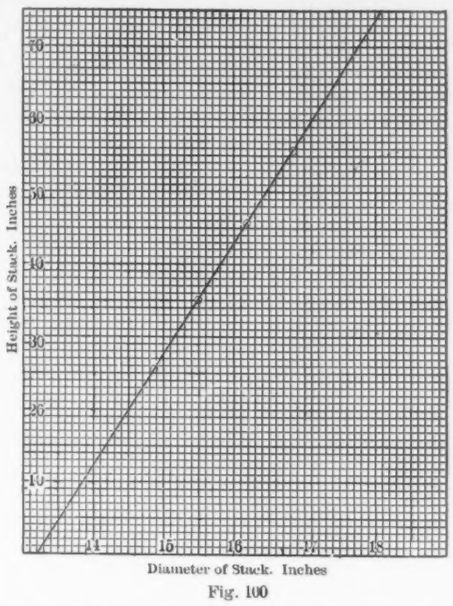


Fig. 100

RELATION OF DIAMETER TO HEIGHT OF STACK FOR THE PURDUE EXPERIMENTAL LOCOMOTIVE FOR BEST RESULTS WHEN EXHAUST NOZZLE IS ON CENTER LINE OF BOILER.

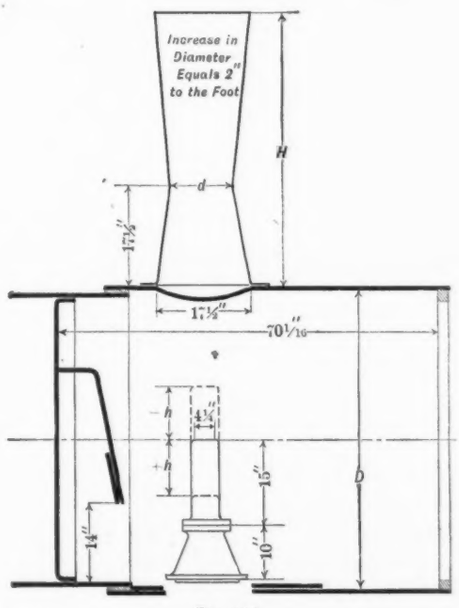


Fig. 101

of this equation to satisfy the condition arising from varying heights of exhaust nozzle will be hereafter considered.

Tapered Stacks.—The best results attending the use of the tapered stacks of each different height experimented upon in connection with the seven different heights of exhaust nozzles, appear in Figs. 96 to 99, inclusive. In these diagrams, the experimental results are shown by means of black spots connected by horizontal lines in the manner already described in connection with the straight stack. When two stacks give equally good results, both points are located and the spots connected by a horizontal line, and where a larger or smaller stack gives results almost as good as the best, a line is extended in its direction terminating in a small spot midway between that representing the best stack and the position representing the stack which is almost as good.

Proceeding, as in the case of the straight stacks, to locate a representative point in line with Nozzle No. 3, which will fairly represent the experimental data, choice has been made of the diameter 13½ ins., and a circle drawn upon all diagrams while at this diameter. It appears, therefore, that an important conclusion to be derived from the experimental data is to the effect that a tapered stack having a least diameter of 13½ ins., gives maximum results for all heights of stack between the limits of 26½ ins. and 56½ ins. In other words, unlike the straight stack, the diameter of the tapered stack does not need to be varied with changes in the height.

Stating this fact in the form of an equation, therefore, we have for a tapered stack upon the Purdue engine, the diameter of the boiler of which is 54 ins., the following:

$$d_a = 13.5;$$

also

$$d_a = 13.5 = .25 \times 54 \text{ ins.}$$

Assuming that the results thus obtained from the experimental engine may be applied to other engines having different diameters of boilers, and using the diameter of the boiler as a unit of measure, we may write for all locomotives, and for all heights of stacks where the exhaust tip is on the center of the boiler:

$$d = .25\ D$$

in which d is the least diameter of the tapered stack when the exhaust tip is on the center line of boiler and D is the diameter of the front-end of the boiler.

Expressing this relation in words, it is to the effect that when the exhaust nozzle is on the center line of the boiler, the least diameter of tapered stack should be one-quarter the diameter of the front-end of the boiler.

41. *The Effect of Changes in the Height of the Exhaust Nozzle upon the Diameter of Stack.*—For the purpose of passing from the results obtained from the experimental engine to

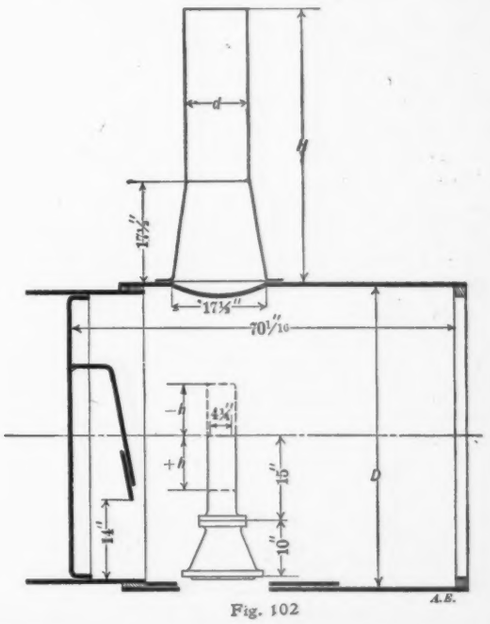


Fig. 102

those to be expected from engines having boilers of other diameters, using the boiler diameter as a unit of measure, it has been necessary thus far to deal with conditions for which the parts are symmetrically arranged. It is for this reason that the central position of the nozzle is the only position which has been employed. We may now consider the influence upon the diameter of the stack resulting from changes in the height of the nozzle.

The points represented by the circles (Figs. 92 to 99) and which have been the basis of equations thus far written, have been so located that it is possible to draw through each of them a straight line which will fairly represent the best diameter of stack for all heights of nozzles. The oblique line which appears in the several figures may be regarded as such a line. It now remains to find an expression for this line which can be added, as a new term, to the equation which has already been deduced, for the purpose of modifying the final results as demanded by the differences in results obtained when changes are made in the height of the nozzle.

Straight Stacks.—In Figs. 92 to 95, inclusive, representing the straight stacks, the oblique lines representing the relationship between diameter of stack and height of nozzle as dis-

closed by the experimental data have all been drawn straight and at a constant angle. The slope of the line is such that assuming the effect of the nozzle in Position 3 to be zero, the effect upon the diameter of the stack of each inch change in the height of the exhaust nozzle equals .19 of an inch. It is evident that this correction will effect an increase in the diameter of the stack when the nozzle position is below the center line of the boiler, and a decrease in the diameter of the stack when the exhaust nozzle is above the center line of the boiler. We may, therefore, write as a new term in the equation giving the best diameter of a straight stack,

$$.19\ h$$

in which h is the distance in inches between the center line of the boiler and the exhaust tip, the sign preceding this term being positive when h is the distance below the center line, and negative when h is the distance above the center line.

Tapered Stacks.—A similar process gives the constant representing the change in effect to changes in the height of the nozzle for the tapered stack, excepting that for this stack, the slope of the line (Figs. 96 to 99) is different and the constant is different. Its value is represented by .16. Thus, to measure the effect of changes in the height of nozzle on the diameter of the stack, we may, for the tapered stack, write:

$$.16\ h,$$

the sign preceding the term being postive when h is distance below the center line and negative when h is distance above the center line.

42. *Equations Giving Stack Diameters for Any Height of Stack between the Limits of 26 Ins. and 56 Ins., and Any Height of Nozzle between the Limits of 10 Ins. Below the Center of the Boiler and 20 Ins. Above the Center of the Boiler, and for Any Diameter of Front end.*—Combining the expressions of the two preceding paragraphs, we may have equations giving diameter of stack in terms of its height, diameter of front-end, and the distance between the center-line of the boiler and the top of the exhaust tip. These several equations obviously are the equations of the oblique lines appearing in the corresponding diagrams, Figs. 92 to 99. They are as follows:

For Straight Stacks:

When the exhaust nozzle is below the center line of the boiler,

$$d = (.246 + .00123\ H)\ D + .19\ h.$$

When the exhaust nozzle is above the center line of the boiler,

$$d = (.246 + .00123\ H)\ D - .19\ h.$$

When the exhaust nozzle is on the enter line, h is equal to zero and the last term disappears, and there remains,

$$d = (.246 + .00123)\ D.$$

For Tapered Stacks:

When the nozzle is below the center line of the boiler,

$$d = .25\ D + .16\ h.$$

When the nozzle is above the center line of the boiler,

$$d = .25\ D - .16\ h.$$

When the nozzle is on the center line of the boiler, h becomes zero, and

$$d = .25\ D.$$

In all of these equations, d is the diameter of the stack in inches. For tapered stack it is the least diameter or diameter of "choke." H is the height of stack in inches and for maximum efficiency should always be given as large a value as conditions will admit. D is the diameter of the front-end of the boiler in inches, and h the distance between center line of boiler and the top of the exhaust tip.

The fact is worthy of all emphasis that H should always be made as great as possible.

If D in the several equations is made equal to 54, the diameter of the front-end of the Purdue locomotive, the equations will give results identical with those which are assumed to represent the maximums obtained in the course of the experiments. How far they should be employed in the manner which has been indicated for engines having a boiler different in size can not, of course, be stated with certainty, though the undersigned is of the opinion that where the conditions surrounding stack and nozzle are similar, they may be depended upon to give satisfactory results for any diameter of front-end now in use or likely soon to come into use. What the conditions are which should be observed in the use of the equations is best shown by Figs. 101 and 102.

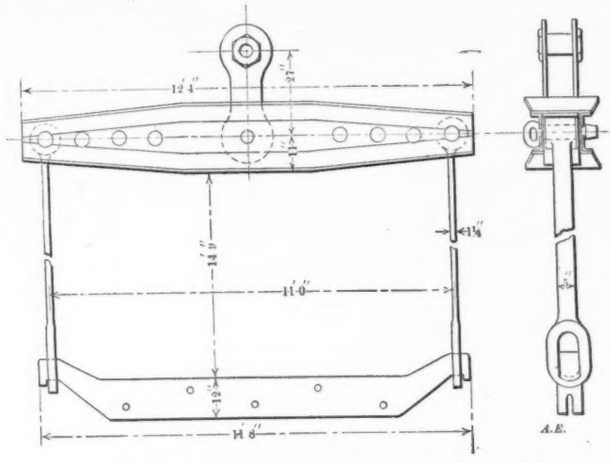
In this connection, also, it should be noted that it is not claimed that the plain stack and nozzle, as shown, will give better results than some other arrangement, but merely that when the plain stack and nozzle are used, the equations will give the best relation of diameter to height which is obtainable. It is this question only that the experiments were designed to cover. Whether, for example, as a general proposition, the application of draft or petticoat pipes will improve the draft, or whether they will affect the relation of height and diameter of stack as already establisned, can not be determined from the present work.

(To be Continued.)

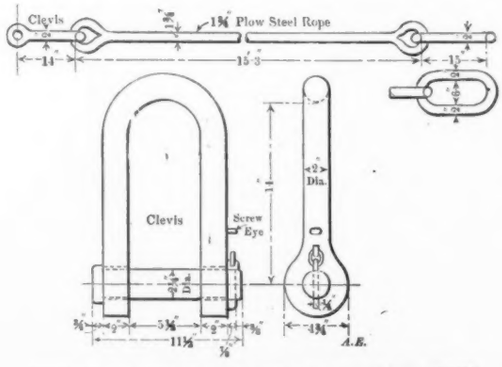
CRANE BEAM AND SLINGS.

FOR 50-TON TRAVELING CRANES.

On looking up, in the technical papers, the subject of crane slings and beams for handling locomotives in erecting shops, a correspondent discovered a scarcity of information upon the subject and suggested the advisability of putting on record the construction of these details. Through the courtesy of Mr. Charles E. Turner and W. R. Maurer, of the Buffalo, Rochester & Pittsburg Railway, the accompanying engravings of the



DETAILS OF A BOX-GIRDER BEAM AND THE SLINGS.



DETAILS OF THE CLEVIS FOR A STEEL ROPE SLING.

lifting beam and rope slings for the Du Bois shops of that road are presented.

The sling is designed for a capacity of 50,000 lbs., and two were provided. The rope is of steel wire, the eye splices at the ends being made by the manufacturers of the rope. The lifting beam is a box girder, built up of angles and plates of the dimensions indicated. The Du Bois shops have longitudinal tracks.

THE APPLICATION OF INDIVIDUAL MOTOR DRIVES TO OLD MACHINE TOOLS.

McKEES ROCKS SHOPS.—PITTSBURGH & LAKE ERIE RAILROAD.

BY R. V. WRIGHT, MECHANICAL ENGINEER.

II.

Upon machine tools such as lathes, boring mills, etc., which handle work of varying diameter, the horse-power required is practically constant over wide ranges of speed. An ideal motor for such machines would be one in which the torque increases as the speed decreases. The torque of a motor is practically constant, however, and the horse-power varies directly as the speed.

If, for instance, a certain horse-power is required through a range of speed of 8 to 1, the motor, in order to furnish full power at its lowest speed, would be required to have a capacity which, at the highest speed, would be equal to eight times as much as the power required. This would, of course, be modified somewhat, if the speed range of the motor was increased by weakening the field. But as the field is weakened and the speed thus increased, the horse-power falls off rapidly. Thus, if the required range of speed is large, and the entire range is

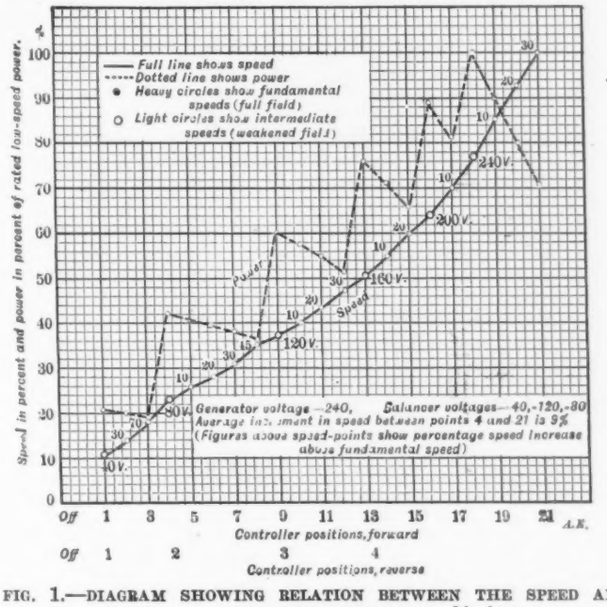

Full line shows speed
Dotted line shows power
Heavy circles show fundamental speeds (full field)
Light circles show intermediate speeds (weakened field)
Generator voltage—240, Balancer voltages—40,-120,-80
Average increment in speed between points 4 and 21 is 9%
(Figures above speed-points show percentage speed increase above fundamental speed)
Speed in percent and power in percent of rated low-speed power.
Power
Speed
Controller positions, forward
Controller positions, reverse
A.E.

FIG. 1.—DIAGRAM SHOWING RELATION BETWEEN THE SPEED AND POWER OF A MOTOR USING THE M. F. 21 (FIELD WEAKENING) CONTROLLER.

furnished through the motor, a large and bulky motor will be required, and, furthermore, it will not be very efficient at the lower speeds.

With the Crocker-Wheeler Company's multiple voltage system, in cases where machine tools require a wide range of speed with a constant horse-power throughout, part of the range is taken by the motor and part by runs of gearing interposed between the motor and the machine. This system allows the use of a comparatively small motor whose average efficiency is greater than in the case cited above, since it need not be run at such comparatively low speeds.

A complete description of the Crocker-Wheeler four-wire multiple-voltage system will be found on pages 23 and 24 of the January, 1903, issue of this journal. For the McKees Rocks shops installation, the controller which is illustrated and described on page 24 of the January issue, and which is known as the M. A. 12 controller, will be used on part of the machines only. For certain machine tools, such as lathes, on which we wish to have a large number of speed changes, the M. F. 21 type of controller will be used.

The intermediate speeds between any two voltages are obtained in the M. A. 12 controller, by changing the armature resistance; this arrangement allows only one intermediate speed between any two voltages. The intermediate speeds with the M. F. 21 controller are obtained by weakening the field, and several intermediate speeds can be obtained between any two voltages. Furthermore, the intermediate speeds are more stable with the M. F. 21 controller, although the power at the intermediate speeds is reduced somewhat. Fig. 1 shows diagrammatically the relation between the speed and the power for the M. F. 21 controller, and Fig. 2 shows this relation for the M. A. 12 controller.

Let us now consider the case of the application of a motor to lathe No. 6. This is a 20-in. Reed lathe, the data for which, as belt driven, is shown on page 125 of the April issue of this journal. We wish to have a range of speed upon this tool of from 8 to 240 rev. per min. The class of work to be done on this lathe will not be very heavy and it was decided to fit it up for a capacity of taking a ¼-in. cut with a 1-32-in. feed on hard steel at a cutting speed of 50 ft. per minute.

The maximum horse-power required to do this work $= 1\text{-}32 \times \frac{1}{4} \times 50 \times 12 \times 1 \times .7 = 3\frac{1}{4}$. (See formula on page 125 of the preceding article of this series.) Since the work is of a variable diameter, it will require 3¼, or say 3 horse-power, throughout the entire speed range. The question which naturally presents itself is: Can we make use of the gearing now on the lathe in connection with the application of the motor? The present back gear ratio is 10.7 to 1. Assume that the motor is con-

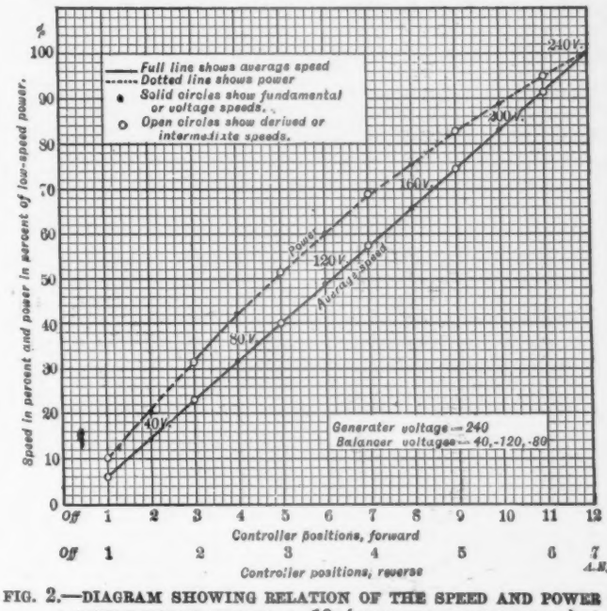


FIG. 2.—DIAGRAM SHOWING RELATION OF THE SPEED AND POWER OF A MOTOR USING THE M. A. 12 (ARMATURE RESISTANCE) CONTROLLER.

nected so as to drive the main spindle at 240 revolutions per minute. Now, if the back gear is thrown in, the spindle speed will be $240 \div 10.7 = 22.4$ revolutions per minute. In order to fill in the gap between 25 and 240 revolutions per minute the motor would be required to have a speed range of about 9.6 to 1. Referring to Fig. 1, it will be found that when the motor is running at 10.4 per cent. $\left(\frac{1}{9.6}\right)$ of its maximum speed, or the lowest speed, it will furnish about 20 per cent. of its rated power. Therefore, in order to furnish 3 horse-power throughout the range, a 15 horse-power motor would have to be used. A motor of this size would be very large and bulky for a 20-in. lathe and would not be very efficient at the lower speeds.

With the required power and range of speed, can we change the number of teeth in the present gears and use a smaller motor?

Two hundred and forty to 8 revolutions per minute is a range of 30 to 1. For such a range the motor and the run of gearing would each have to cover a range of speed of about 5.5 to 1. Referring again to Fig. 1, it will be found that the motor at 18 per cent. $\left(\frac{1}{5.5}\right)$ of its maximum speed, furnishes prac-

tically the same percentage of power as in the case considered above, and so we are really not much better off.

Suppose then we add another run of gears. The motor and each run of gears would be required to have a range equal to the cube root of 30, or about 3.108 to 1. The spindle speeds would run thus:

	Maximum.	Minimum.
First run	240	77.3
Second run	77.3	24.9
Third run	24.9	8.0

It would be just as well, however, if there were a jump of speed between the different runs of gearing equal to the 10 per cent. speed increments furnished by the controller. Reduce the speed range of the motor 10 per cent., or from 3.108 to 1 down to 2.79 to 1, and the spindle speeds will run thus:

	Maximum.	Minimum.
First run	240	86
Second run	77.3	27.8
Third run	24.9	8.93

The lower speed limit is increased somewhat, but this can easily be remedied by changing the ratios slightly. The motor could, of course, be run at a still lower speed, but at reduced power.

Referring again to Fig. 1, it will be found that when the motor is running at 36 per cent. $\left(\frac{1}{2.79}\right)$, of its maximum speed, it furnishes 60 per cent. of its total power. Therefore, in order to have 3 horse-power available throughout the range, a 5 horse-power motor will have to be used. At controller points 10, 11 and 12, it will run a little below 3 horse-power, but the motor will run at full power at these points a small part of the time, only, and it can easily take care of the slight overload.

A chart similar to the one shown in Fig 3 will be found very

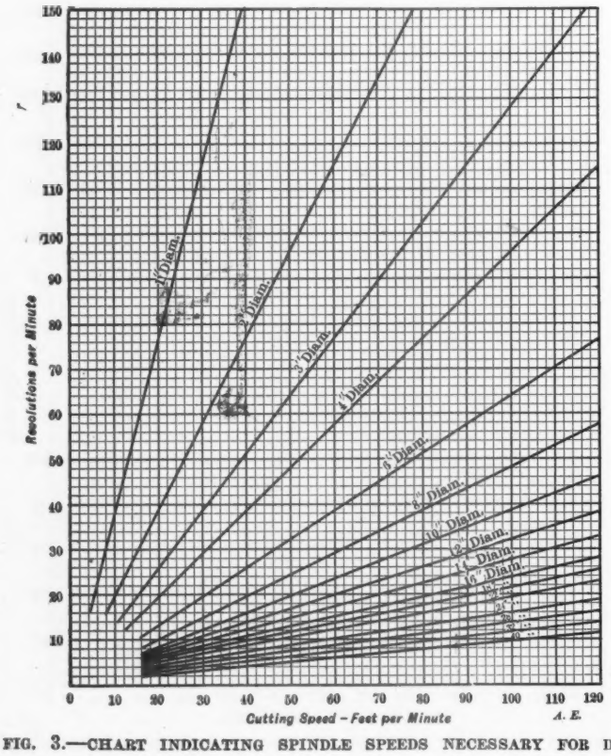


FIG. 3.—CHART INDICATING SPINDLE SPEEDS NECESSARY FOR DESIRED CUTTING SPEEDS WITH WORK OF VARYING DIAMETERS.

useful in determining the spindle speeds for all cutting speeds with work of various diameters.

When two runs of gearing are used in connection with the motor, the arrangement shown in Fig. 4 is very convenient. X and Y, in the engraving, represent a double and single jaw clutch respectively. Gears F, C, B and H run loose on the main spindle. B is keyed to an extension of gear C. When X is thrown to the left, the motor drives the main spindle direct. When X is in the center and Y is thrown to the right, the reduction is through $\frac{A}{B} \times \frac{C}{D} \times \frac{E}{F}$. When Y is out and X is thrown to the right, the drive is through $\frac{A}{B} \times \frac{C}{D} \times \frac{G}{H}$.

Figs. 5 and 6 show in detail the double jaw clutch used. These clutches are made of cast steel and have only three jaws, which are large and substantial. The corners of the teeth are beveled off and the teeth have 1-16-in. play in the cavities into which they fit. This allows the clutch to be thrown in while the lathe is slowing up and before it has come to a full stop.

With the arrangement shown in Fig. 4, all the gears will be running all the time the lathe is in operation. The idle gears will, however, run at a slow speed and the greater part of the time only one pair will run idle since the lathe will work on one of the two slower runs most of the time. The wear on the gears while running idle will not amount to much. This slight disadvantage can be overlooked when we consider the

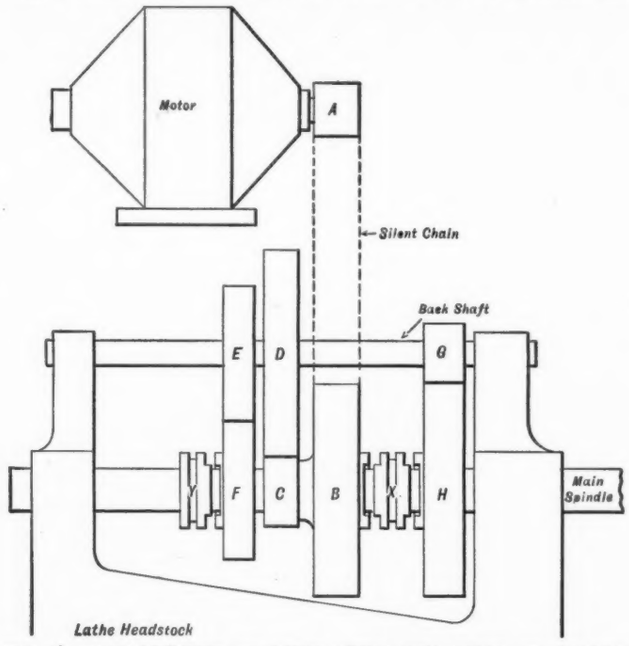


FIG. 4.—ARRANGEMENT OF DRIVE WITH TWO RUNS OF GEARING GIVING THREE SPINDLE SPEEDS FOR EVERY MOTOR SPEED.

ease with which the change can be made from one run of gears to either of the others.

If, instead of clutches, the gears themselves were to be shifted on the shaft, it would be necessary to bring the lathe to a dead stop and then move the machine slightly backward or forward in order to get the teeth to mesh.

In place of bronze bushings for the cast steel parts which run loose on the shaft, babbitt metal will be used as shown in the drawing of the jaw clutch in Fig. 6. This is not as good practice, but in several cases we found that it would be very inconvenient to allow enough room to take in a bushing.

Fig. 7 shows the motor attached to the lathe. The brackets which support the motor are cast with chipping strips where they fit against the headstock. The motor is connected to the main spindle as indicated by a 2¼-in. Morse silent chain. This is easily applied and furnishes a very convenient method of making the speed reduction.

With a vertical chain-drive it is necessary to have some means of taking up the slack, as the chain wears. We expect to do this by placing shims under the motor feet. The same result may be accomplished by fitting a set screw with a lock nut into the motor bracket, with the point of the screw pressing upward against the motor foot, so as to adjust the height thereof. The motor would be held to the bracket by through bolts as before. With a horizontal drive the weight of the chain itself, of course, provides for the slack.

With the use of the silent chain it is advisable to have an uneven number of teeth in both chain sprockets in order to

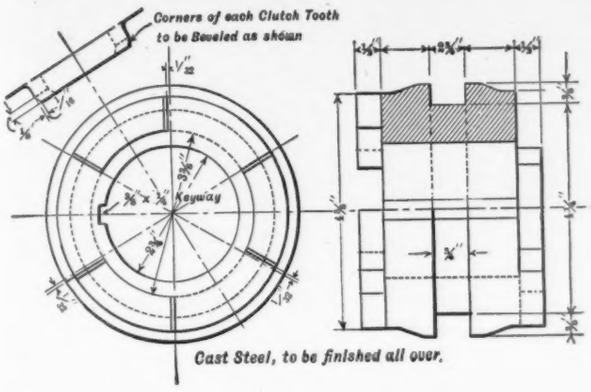


FIG. 5.—DETAILS OF THE DOUBLE JAW STEEL CLUTCH.

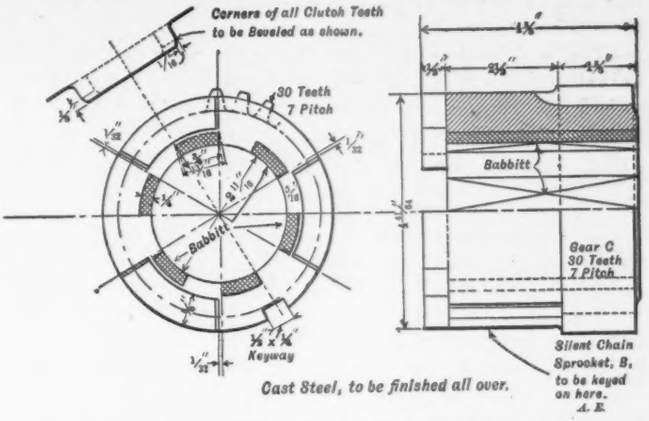


FIG. 6.—DETAILS OF THE SINGLE-JAW CLUTCH, TO CARRY SILENT CHAIN SPROCKET AND GEAR—C.

keep the wear on the sprocket teeth even. It is advisable with a motor drive to have an uneven reduction from the motor in any case, whether it is made by silent chain or gears; otherwise, if the work is regularly intermittent (the cut on a piece in a lathe, for instance, might be light except at one part of the revolution where it might be very heavy), an excessive torque may be necessary at one point of the revolution, and if it comes on the same commutator bar each time it will cause a bad sparking and eventually ruin that commutator bar.

In designing new gears and in checking over the strength of such old ones as we found it possible to use, the formula, $W = s\ p\ f\ y$, devised by Wilfred Lewis (see Kent's Pocket Book, page 901), was used. Comparing this with the practice followed by some of the tool builders we found that it gave a rather low value for the strength, and, therefore, in several cases where the load on the gears was steady we used somewhat higher values, for the safe working strength for different speeds, than those given in connection with the formula.

The sizes of keys were determined by reference to table on page 976 of Kent's Pocket Book, entitled, "Size of Keys for Machine Tools." The sizes for sliding feathers were determined from Table III. on page 977 of Kent's Pocket Book.

In order to prevent a careless workman from throwing in the two opposing clutches at the same time an interlocking device was devised by our chief draughtsman, Mr. W. P. Richardson. This mechanism is illustrated in Figs. 7 and 8.

A and B are the handles of the two levers which operate the

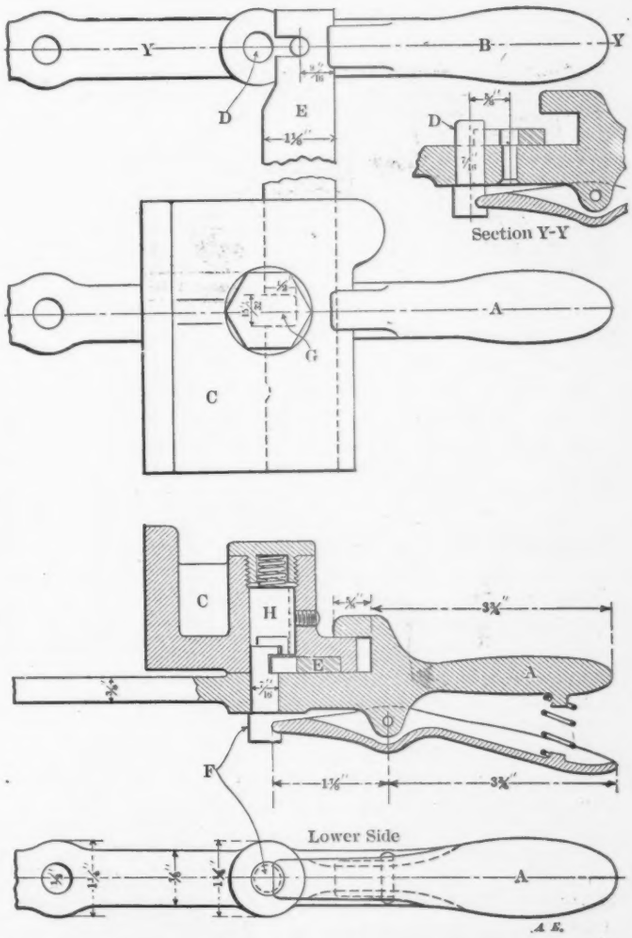


FIG. 8.—DETAILS OF CLUTCH HANDLE INTERLOCKING MECHANISM.

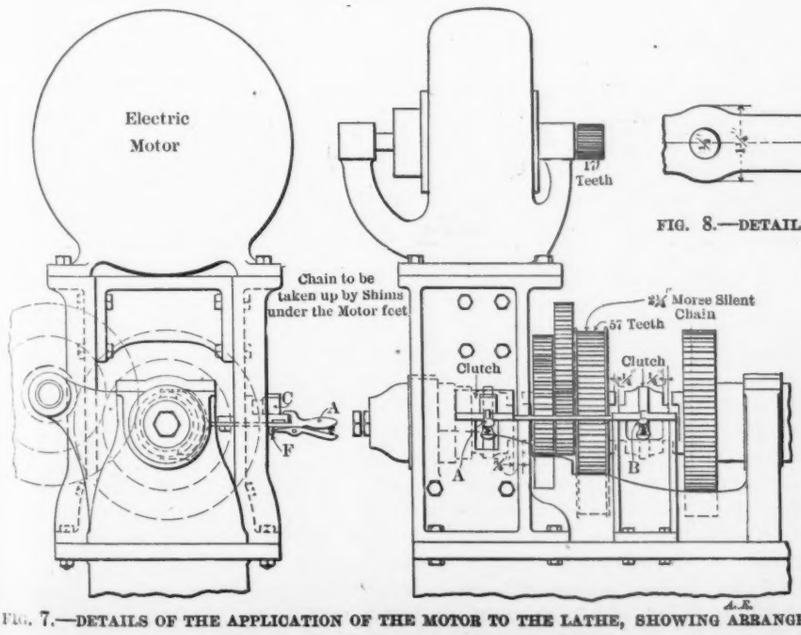


FIG. 7.—DETAILS OF THE APPLICATION OF THE MOTOR TO THE LATHE, SHOWING ARRANGEMENT OF INTERLOCKING CLUTCH HANDLES.

clutches on the main spindle of the lathe. C is the latch bracket for lever A, and carries the locking mechanism. The latch bracket for lever B is a plain bracket (not shown), merely provided with holes for engaging the latch pin D.

E is a latch bar pinned to lever B, and slides freely in a groove of the bracket C when the lever A is in its mid position, and the clutch it operates is thus disengaged.

Any side movement of the lever B slides the bar E so that it engages in the slot in latch pin F and thus locks lever A; the latter remains locked until the lever B is

returned to its central position and the clutch operated by it is thus disengaged.

When B is in its central position, the bar, E, is moved along so that the latch pin, F, may be drawn past it through the slot, G, and the lever, A, thus unlocked. But, in so doing, the stop pin, H, no longer held up by the latch pin, F, has been forced down by the spring above it, into slot, G, and the bar, E, is securely locked; this in turn locks lever, B, in its central position with its clutch out.

(To be continued.)

STEEL CARS ON THE BESSEMER & LAKE ERIE RAILROAD.

A complete record of steel car construction in this country would be valuable and interesting. Its value would be greatest in showing that some of the earliest designers in this field worked out ideas the importance of which is only now admitted or recognized. The record would reveal a number of backward steps and it would impress the importance of knowing what has been done in order to retain continuity of progress.

By special request for a record of the designs which have impressed themselves upon the construction of this equipment, drawings and information have been secured showing the development upon the Bessemer & Lake Erie Railroad, the pioneer in this country in the use of steel cars on a large scale.

THE FOX STEEL FLAT CAR—1894.

The credit belongs to Mr. Charles L. Taylor, who has been connected with the Carnegie interests for more than twenty years and is now chairman of the Carnegie Relief Fund. While traveling in Europe early in 1894, Mr. Taylor became thoroughly impressed with the successful use of steel in car construction on the Continent and returned to this country firmly convinced that the time for large capacity steel cars had arrived. He had been closely identified with the first manufacture of soft Bessemer steel in this country as superintendent of the Homestead Steel Works from 1882 to 1886. During this period the transition from iron to steel in the manufacture of ship plates, bridge and structural material had been most marked, these works having been pioneers in this development.

The Havre de Grace bridge of the Baltimore & Ohio Railroad was the first Bessemer steel structure in this country, and it converted Rear-Admiral Robley D. Evans to this material. He was the inspector of the steel for that structure and had much to do with introducing soft steel plate and developing its manufacture for vessels of the navy. With the growth of the demand the manufacturers were prepared for extending the manufacture, and thus the shipbuilding interests and others using soft Bessemer steel had an important influence on the steel-car situation by rendering the steel car possible commercially.

In 1894 the first step in the large scale development of the steel car was taken. It was not taken by a railroad but by a steel company, and since that time the use of steel in this construction has increased with marvelous rapidity. During the three years from 1900 to 1902, inclusive, the Carnegie Steel Company alone has furnished about 1,000,000 tons of steel for car construction, over 400,000 tons having been shipped during the year 1902. Other companies have added their quota, but these figures serve to show the growth of the industry. Up to January 1, 1903, the total output of the six largest manufacturers of steel cars has been 96,021 all-steel cars, not including cars with steel underframes.

It is difficult to believe that well-known high officials of our railroads only eight years ago ridiculed and discouraged the introduction of steel in this direction, but this is true. Only six years ago railroad men considered the steel car movement merely a selfish effort of a steel company to find another market for their product for steel plates. One year later, however, the Pittsburg, Bessemer & Lake Erie Railroad was quite willing to make an investment of over $1,000,000 in steel cars. It was a bold step, and in the light of subsequent experience it reflects great credit upon all concerned. From this beginning there developed a special branch of structural engineering in which many millions have been invested and many thousands of men employed.

FOX STEEL FLAT CARS, 1894.

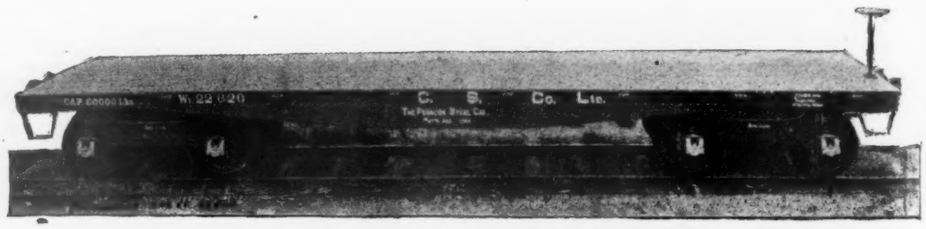
In the autumn of 1894 the Carnegie Steel Company received from the Fox Solid Pressed Steel Car Company, of Joliet, Ill., seven steel flat cars of 80,000 lbs. capacity. These were designed jointly by officers of both of these companies; they were exhibited at the convention of the Master Car Builders' Association at Saratoga, N. Y. They have been in continuous service for the Carnegie people and are now in daily use, giving entire satisfaction in carrying rough and finished steel products. Drawings of these cars are not now available, but the engravings show their appearance. They were built of rolled shapes, without truss rods, and decked with planks, and were of the following dimensions:

Fox Steel Flat Cars, 1894.

Length over end sills	34 ft. 1 in.
Length between truck centers	24 ft.
Wheel base of trucks	5 ft. 2 ins.
Width over decking	8 ft. 7½ ins.
Width over stake pockets	9 ft. 5 ins.
Height of deck from top of rails	3 ft. 11½ ins.
Capacity	80,000 lbs.
Weight of No. 1002	26,220 lbs.
Weight of No. 1007	25,150 lbs.

PENNOCK FLAT CARS, 1895.

An outcome of numerous interviews between Mr. Charles L. Taylor and Mr. Willard Pennock, of Pennock Bros., Minerva Car Works, Minerva, Ohio, was the construction of a Pennock all-steel flat car purchased by the Carnegie Steel Company in June, 1895. This car was rated with a capacity of 60,000 lbs., and was tested at Pittsburg in July, 1895, with a load of 118,000 lbs. of steel billets, giving a deflection at the center of ⅝ in. This car was constructed of fish-bellied steel channels placed side by side, the webs forming the floor and the flanges being secured together by rods extending across the car, forming longitudinal ribs extending the full length of the car. The construction is illustrated by the accompanying engraving. This car weighed 22,620 lbs. Its center was reinforced by a 12-in. I beam split in the center, each half being used as a center

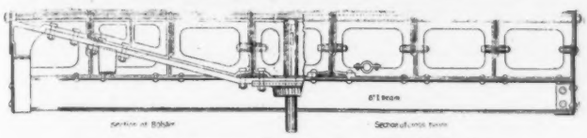


THE PENNOCK STEEL FLAT CAR—1895.

sill. This car is still in service. It has given entire satisfaction for seven years, and is apparently good for a great many more years.

FIRST STEEL HOPPER CAR, 1896.

A wooden hopper coal car, designed and built by the Pennsylvania Railroad in 1895, has exerted a strong influence on



CROSS SECTION OF THE PENNOCK CAR.

the design of steel cars. This was the first hopper car on that road and it is believed to be the first large car of this type. In the Pennsylvania classification it is known as the "G g" car. More will be said about it later.

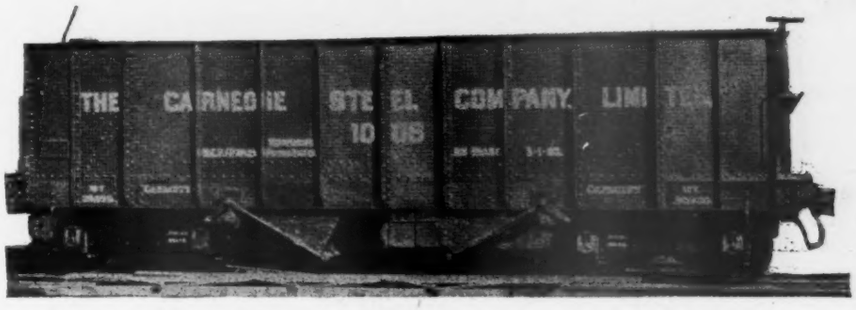
In the design of the first steel hopper cars by the Carnegie Company the chief features of the Pennsylvania "G g" car were closely followed. In fact, the officers of that road were consulted at the time, though they were not quite ready to go ahead in steel construction. The experience of the Carnegie Company with their steel flat cars, which had repeatedly transported armor plate across the continent to the shipyards of the Pacific coast, led them to advance with confidence, their next step being the construction of two large steel hopper cars of structural shapes and plates, the work being done at the Keystone Bridge Works of the Carnegie Company in 1897. These cars were designed by Mr. Charles L. Taylor, ably assisted in the design and construction by Mr. J. B. Hardie. The drawings of these cars show that their capacity was supposed to be 80,000 lbs., but, as the photograph indicates, they were stenciled 100,000 lbs. These cars were exhibited at the Saratoga convention of 1896, and they have been in continuous service on the Pittsburgh, Bessemer & Lake Erie (and its successor, the Bessemer & Lake Erie) since that time, making about 6,000 miles per year in hauling ore from the lakes to the Pittsburgh district.

KEYSTONE HOPPER CARS, 1896.

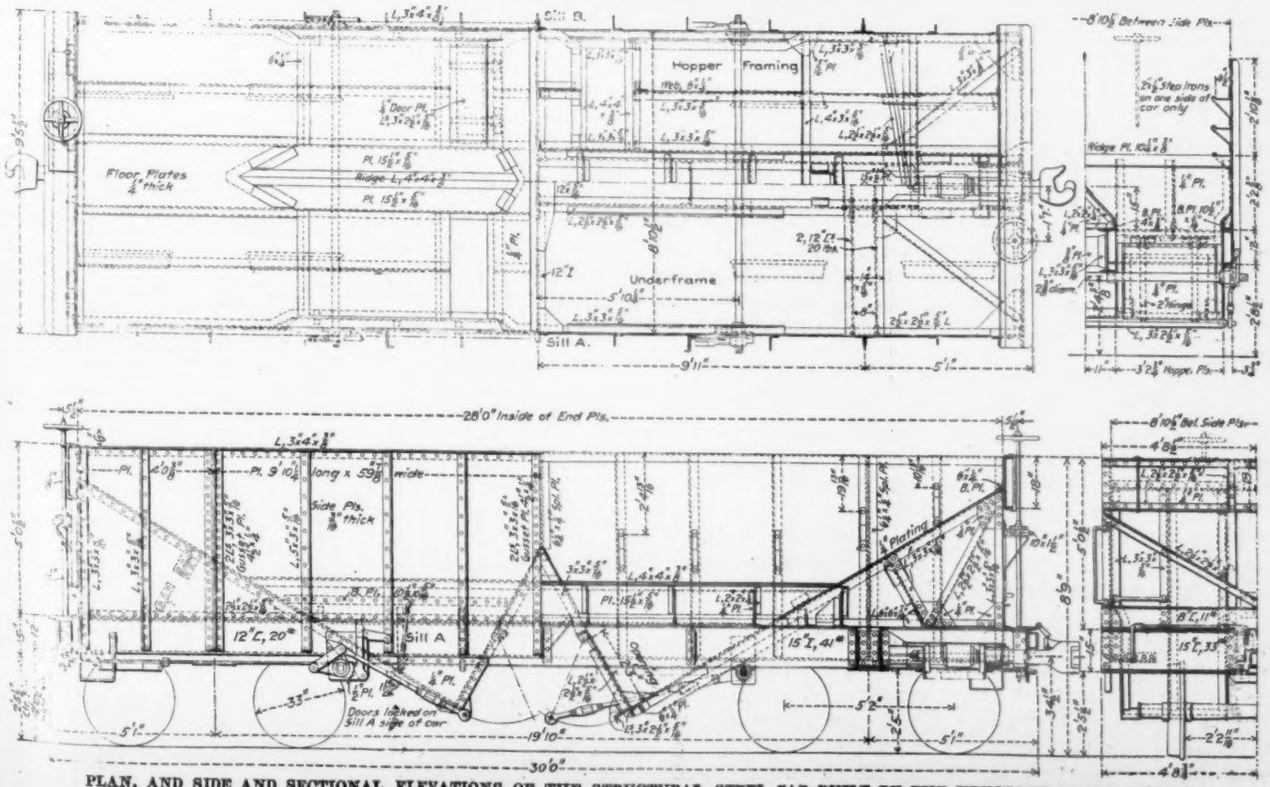
Capacity	100,000 lbs.
Weight	39,950 lbs.
Length over end sills	30 ft.
Length between truck centers	19 ft. 10 ins.
Wheel base of trucks	5 ft. 2 ins.
Width over end sills	9 ft. 5½ ins.
Width, inside	8 ft. 10½ ins.
Length of body, inside	28 ft.
Depth of sides, over sills	6 ft. ½ in.
Height, top of rail to top of sides	8 ft. 9 ins.
Extreme width over grab irons	10 ft. ⅝ ins.

These two cars were mounted on Fox pressed steel trucks and it is specially noteworthy that they were equipped with the Westinghouse friction draft gear, with Carnegie nickel axles and with the hopper door opening devices devised by Mr. G. L. Potter, now general manager of the Baltimore & Ohio Railroad. The builders tested them with a load of 125,000 lbs. of wet sand and found no important deflections. It was stated at that time that their weight could be reduced to 35,000 lbs. with perfect safety. After this test the capacity was stenciled at 100,000 lbs.

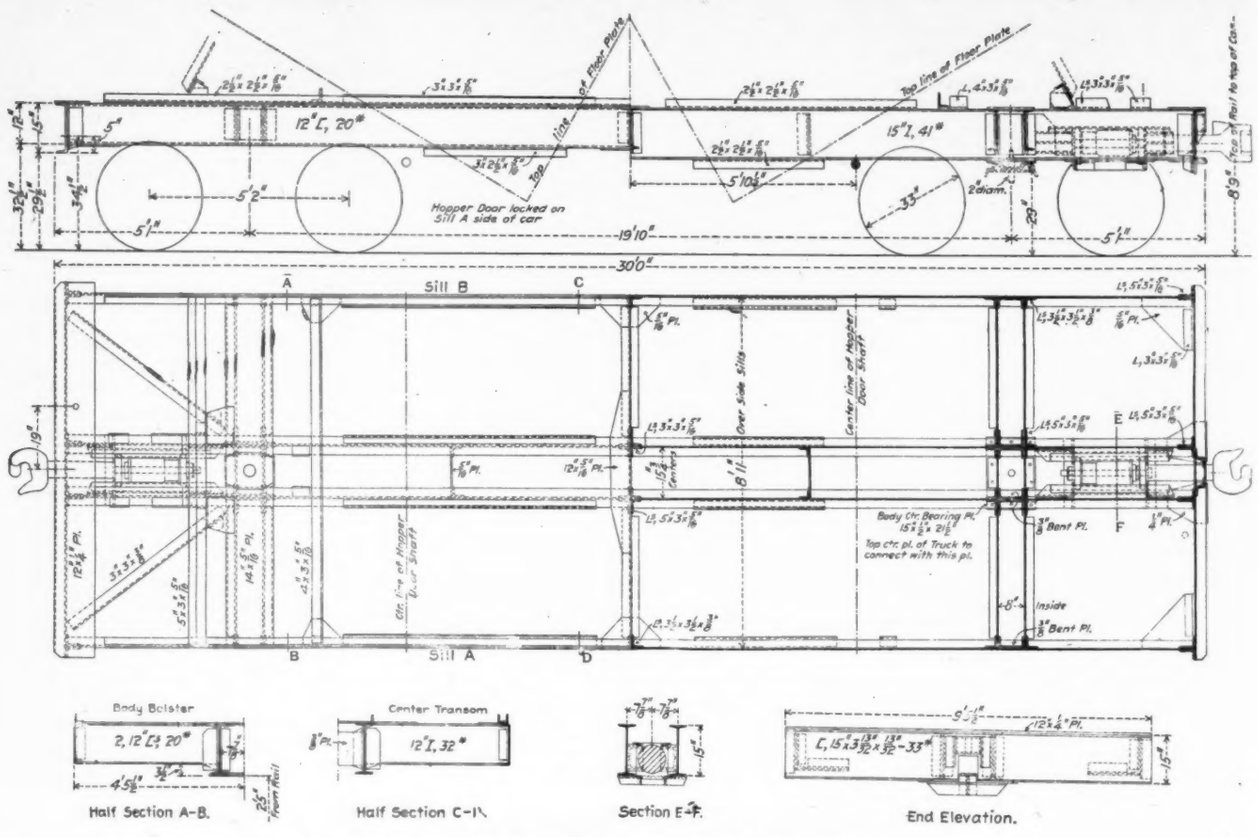
These cars had 15-in. I beam center sills (41 lbs. per ft.) The side sills were 12-in. 20-lb. channels, concealed under the side plates. The end sills were 15-in. 33-lb. channels with ¼ by 12 in. plates riveted to their upper flanges. The body bolsters were 12-in. 20-lb. channels with 5-16 by 14 in. plates secured to their upper flanges; as a center transom a 12-in. 32-lb. I beam was used. The center sills were made continuous from end to end. It is interesting to notice that the underframe is



STRUCTURAL STEEL CAR BUILT BY THE KEYSTONE BRIDGE WORKS—1896.



PLAN, AND SIDE AND SECTIONAL ELEVATIONS OF THE STRUCTURAL STEEL CAR BUILT BY THE KEYSTONE BRIDGE WORKS



DETAILS OF THE KEYSTONE BRIDGE WORKS STRUCTURAL CAR.

a structure by itself and that the hopper construction was built upon it. The drawings of these cars are dated January 22 and January 31, 1896.

The exhibits of these cars by the Carnegie Company at the Saratoga convention in 1896 elicited the interest not only of car builders but of operating officers throughout the country. The claims for the steel car being: Lightness, durability and strength; greater proportion of live to dead weight; longer life; reduced cost of maintenance; less liability to damage and greater salvage value. Experience has verified these claims and the present state of the steel car industry gives proof of the sagacity of the pioneers.

EARLIEST SCHOEN CARS.

On March 26, 1897, the first contract for building steel cars in this country was signed by the Pittsburg, Bessemer & Lake Erie and the Schoen Pressed Steel Company. Up to this time the Schoen Company had confined its attention to small parts of pressed steel. The execution of this contract for 1,000 cars rendered possible the enlargement of the Schoen Company, which has exerted so powerful an influence upon steel car building and has earned the title for the credit for the subsequent development of this industry.

The contract called for the construction of 1,000 hopper cars. Four hundred were built of structural shapes and 600 were from the original design of pressed steel construction by Mr. Charles T. Schoen. This contract was the beginning of the development of large capacity steel cars on a large scale and the pressed steel hopper car has closely followed the first design in cars built since that time. The drawings of the structural car bear the date of January 22, 1897, this design having been developed by Mr. Taylor and Mr. Hardie of the Carnegie Company. The drawing of the Schoen car bears the date of June 20, 1898. Both designs employed the Westinghouse friction draft gear and Carnegie nickel steel axles, having about 3 per cent. of nickel. These axles have given most gratifying results in continuous heavy service. We are informed that only two out of the 4,000 axles in this order have broken in a service of six years. In order to test the construction and utility of various steel trucks these cars were equipped as follows:

STEEL TRUCKS FOR THE FIRST 1,000 STEEL CARS.

Number of Cars.	Design.	Type of Truck.
200	Schoen	Schoen
395	Schoen	Vogt
5	Schoen	Buckeye
600		
100	Carnegie	Schoen
200	Carnegie	Fox
50	Carnegie	Kindl
30	Carnegie	Cloud
10	Carnegie	Vogt
10	Carnegie	Goltra
400		

FIRST CONTRACT FOR STEEL CARS, 1897.

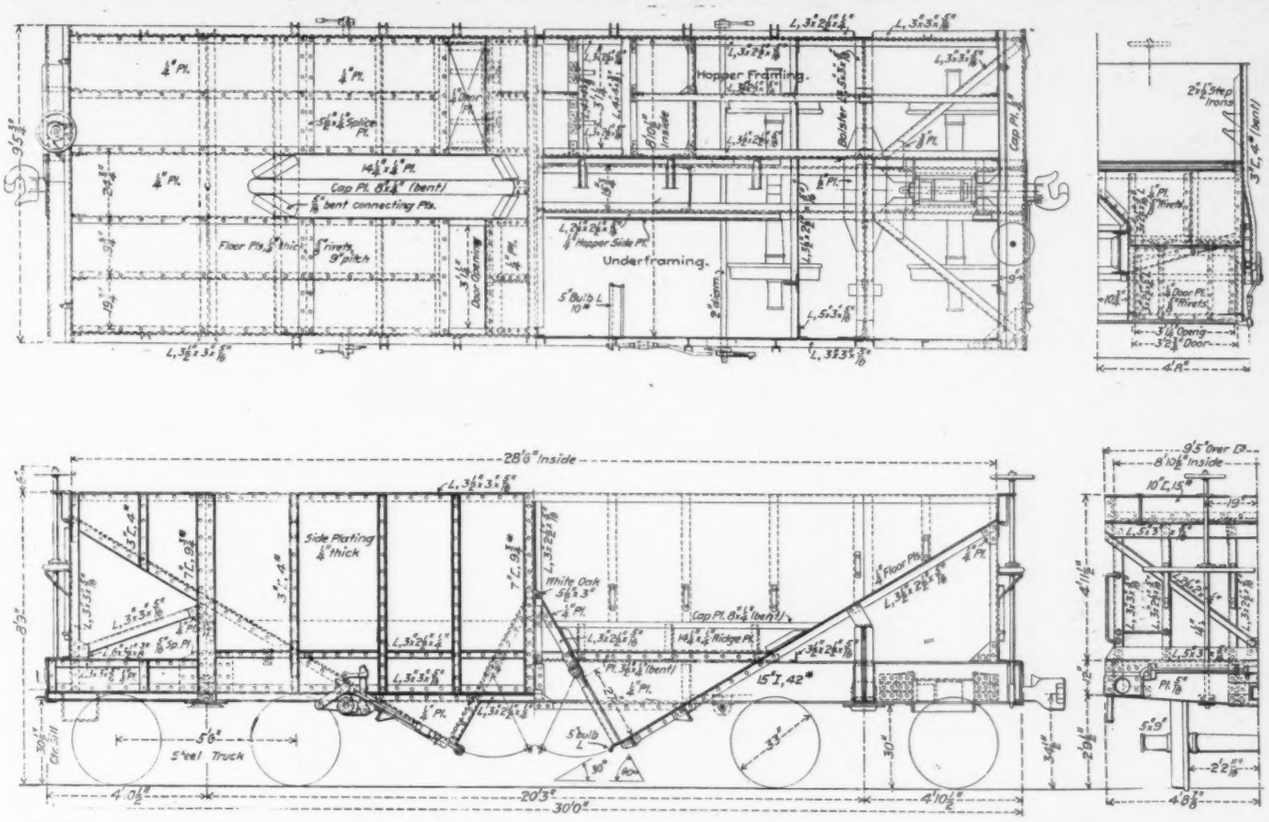
400 CARS, CARNEGIE DESIGN, STRUCTURAL SHAPES.

Capacity	100,000 lbs.
Weight	37,150 lbs.
Length over end sills	30 ft.
Length between truck centers	20 ft. 3 ins.
Wheel base of trucks	5 ft. 6 ins.
Width over end sills	9 ft. 5¾ ins.
Width, inside	8 ft. 10½ ins.
Length of body, inside	28 ft. 6 ins.
Depth of sides over sills	5 ft. 11½ ins.
Height, top of rail to top of sides	8 ft. 9 ins.

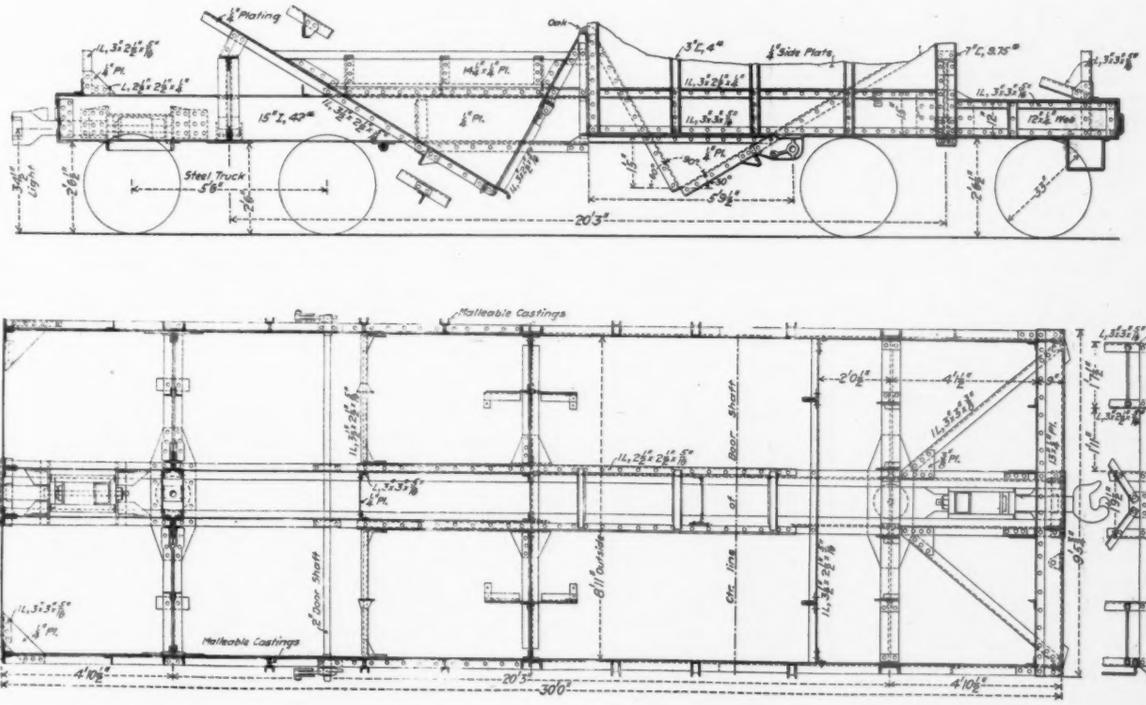
The underframe of this car was based upon 15-in. I beam center sills and had no side sills. Instead of using side sills of structural shapes, the lower portions of the side plates were reinforced by longitudinal angles, as shown in the engravings. This resulted in a construction giving the appearance of 15-in. side sills between the bolsters and 12-in. members from the bolsters to the end sills. This design employed latticed bolsters of the unusual depth of 2 ft. 4 ins., and at the center of the car was a transom of plates and angles. In this car the sides were depended upon to assist in carrying the load, and many designers of more recent date have forgotten this fact.

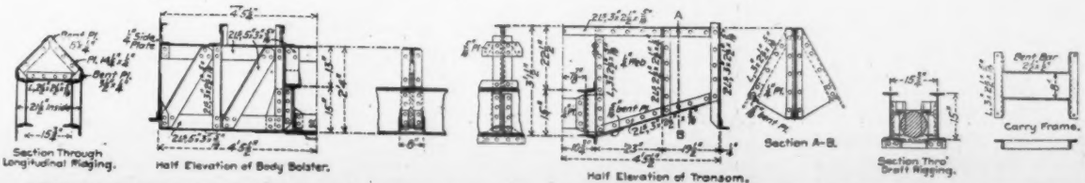
600 CARS, SCHOEN PRESSED STEEL DESIGN.

Capacity	100,000 lbs.
Weight	34,350 lbs.
Length over end sills	29 ft. 6 ins.
Length between truck centers	19 ft. 9 ins.
Wheel base of trucks	5 ft. 7 ins.
Width, over stakes	9 ft. 8 ins.
Width, inside	9 ft. 2 ins.
Length, inside	28 ft. ¼ in.
Height, top of rail to top of sides	8 ft. 9 ins.

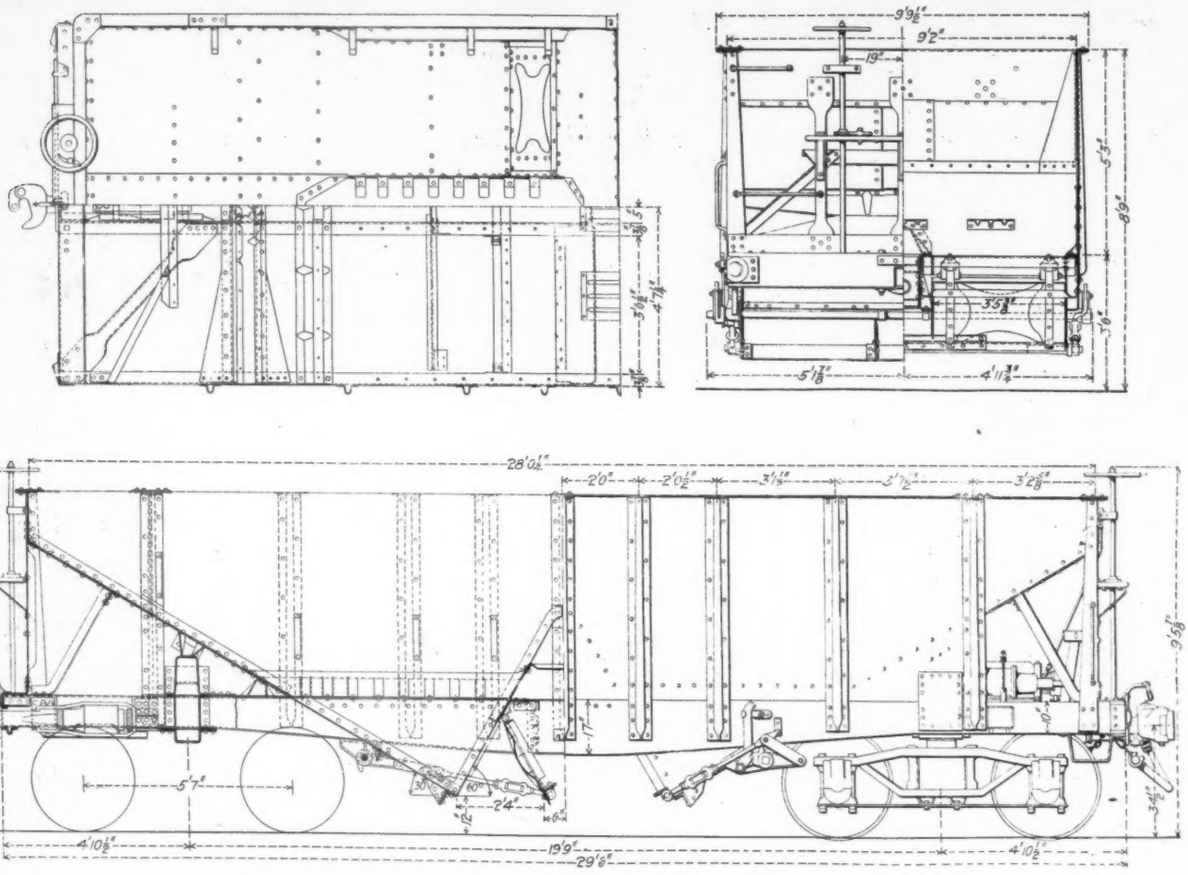


FIRST STRUCTURAL HOPPER CARS BUILT FOR THE PITTSBURG, BESSEMER & LAKE ERIE R. R. BY THE SCHOEN PRESSED STEEL CAR CO., CARNEGIE DESIGN—1897.





DETAILS OF THE ABOVE STRUCTURAL HOPPER CAR, CARNEGIE DESIGN, BUILT BY THE SCHOEN PRESSED STEEL CAR CO.



FIRST SCHOEN PRESSED STEEL HOPPER CARS FOR PITTSBURG, BESSEMER & LAKE ERIE R. R.

This car has the Schoen fish-bellied center and side sills, which are 10 ins. deep at the ends and 17 ins. at the center. The body bolsters are pressed, of trough section, and the construction is in general similar to that which has become so familiar. The trucks shown in this engraving are the Vogt type, with pressed steel arch bars.

ORIGINAL SCHOEN GONDOLA CAR, 1898.

This car was the original of a large number of gondolas built for the Pittsburg, Bessemer & Lake Erie by the Schoen Company. In January, 1903, this road had in service 3,690 hopper and 2,100 gondola cars, all of steel construction, and 1,000 steel gondolas are now being built for the Carnegie interests for use on the Union Railway (of Pittsburg.)

ORIGINAL SCHOEN STEEL GONDOLA CAR, 1898.

Capacity	80,000 lbs.
Weight	29,900 lbs.
Length over end sills	35 ft. 6 ins.
Length between truck centers	24 ft.
Wheel base of trucks	5 ft. 7 ins.
Width over stakes	9 ft. 9½ ins.
Width inside	9 ft. 2 ins.
Length inside	34 ft.
Height of top from top of rail	7 ft. 4¼ ins.
Height of sides, inside	3 ft. 10 ins.

The vital point in the net cost of transportation being directly dependent on the relation of live to dead load, in which cost is involved, economy in tractive resistance; fuel and steam consumption; reduction in train crew forces; reduction in transportation mileage; fewer number of cars

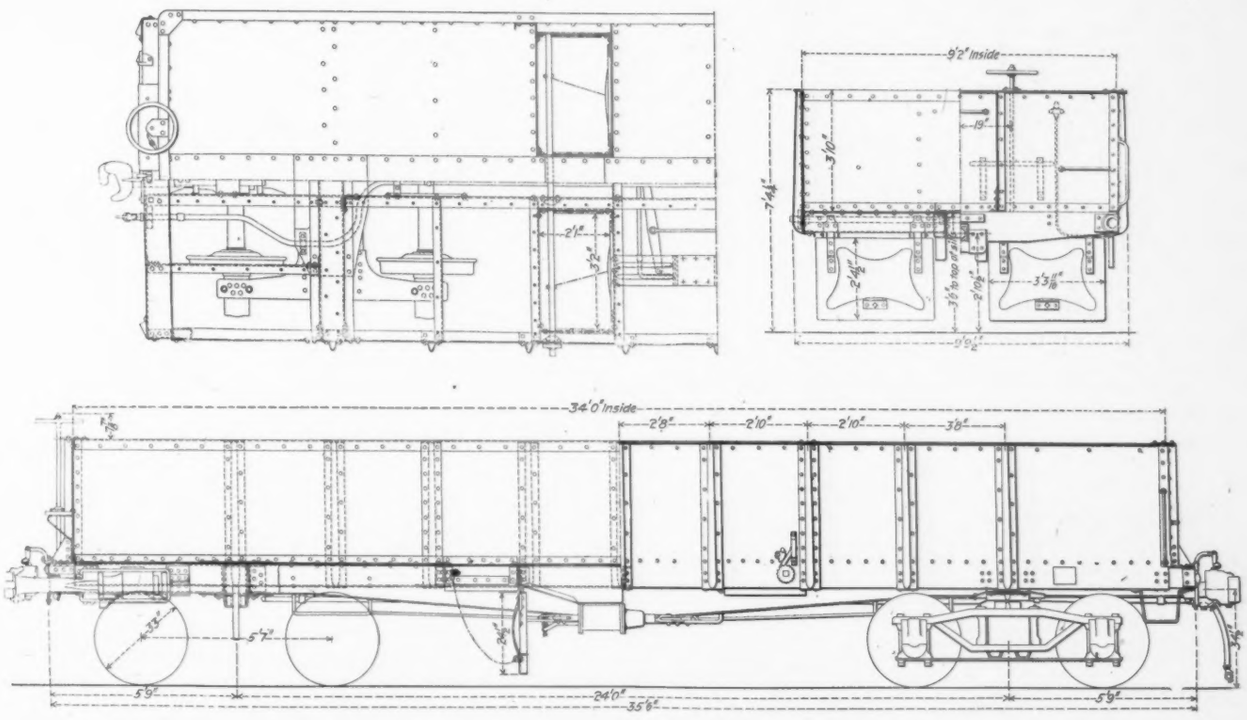
Type of Car.	Individual Capacity (Lbs.).	Individual Dead Weight (Lbs.).	Number of Cars in Train.	Total Train Length (Ft.).	Total Dead Weight Train (Pounds).	Total Live Weight Train (Pounds).	Total Load Hauled (Lbs.).	Ratio of Paying Freight to Total Load Hauled (Per Cent.).
Pennsylvania Railroad wood gondola	28,000	18,500	137	4,345	2,534,500	3,850,000	6,384,500	60.30
Pennsylvania Railroad wood gondola	40,000	24,800	96	3,235	2,380,800	3,850,000	6,230,800	61.80
Pennsylvania Railroad wood gondola	40,000	20,700	96	2,400	1,987,200	3,850,000	5,837,200	65.95
Pennsylvania Railroad wood gondola	40,000	21,000	96	3,600	2,016,000	3,850,000	5,866,000	65.63
Chicago & Northwestern wood hopper	40,000	23,800	96	2,210	2,284,800	3,850,000	6,134,800	62.75
Philadelphia & Reading wood gondola	50,000	23,745	77	2,810	1,828,365	3,850,000	5,678,365	67.81
Southern wood gondola	60,000	26,100	64	2,340	1,670,400	3,850,000	5,520,400	69.74
Baltimore & Ohio wood hopper	60,000	29,700	64	1,860	1,900,800	3,850,000	5,750,800	66.95
Lake Shore & Michigan Southern wood drop-bottom	60,000	27,150	64	2,240	1,737,600	3,850,000	5,587,600	68.91
Norfolk & Western wood drop-bottom	60,000	27,400	64	2,340	1,753,600	3,850,000	5,603,600	68.71
New York, Ontario & Western wood hopper	60,000	25,150	64	1,865	1,609,600	3,850,000	5,459,600	70.52
Individual wood hopper	60,000	23,400	64	1,730	1,497,600	3,850,000	5,347,600	71.99
Baltimore & Ohio lines wood hopper	60,000	30,800	64	2,340	1,971,200	3,850,000	5,821,200	66.13
Erie wood hopper	70,000	33,300	55	2,090	1,831,500	3,850,000	5,681,500	67.77
Hocking Valley wood hopper	80,000	33,600	48	1,800	1,612,800	3,850,000	5,462,800	70.47
Lake Shore & Michigan Southern wood hopper	80,000	36,500	48	1,590	1,752,000	3,850,000	5,602,000	68.73
Pennsylvania Gg. wood hopper	80,000	35,200	48	1,500	1,689,600	3,850,000	5,539,600	69.50
Bessemer & Lake Erie steel hopper	110,000	36,300	35	1,070	1,270,500	3,850,000	5,120,500	75.19
Algoma Central steel hopper	110,000	29,200	35	840	1,022,000	3,850,000	4,872,000	79.03
Duluth & Iron Range steel hopper		29,000	32	755	928,000	3,850,000	4,778,000	80.58

Note.—The cars represented in the table were taken at random and represent a fair average of those in service under their respective classes. Those of the Algoma Central and Duluth & Iron Range represent the most compact modern types of steel hopper cars, but on account of the extremely short wheel base, concentrating the load on a short span, the limit of their operations must be confined to the roads for which they were constructed.

to handle and repair; and reduction in equipment of cars, wheels, axles and other accessories connected therewith, and so on down to a saving in track equipment, all of which advantages were apparent during the early stages of the development of the steel car, is shown by an increase of about 20 per cent. in the ratio of paying freight to total load hauled. The tabulation presented above details this increase.

Assuming a standard ore train on the Bessemer & Lake Erie Railroad made up of 35 steel hopper cars as a basis, the total load hauled being 1,925 net tons, or an average of 55 net tons (110,000 lbs.) per car, the advantages of the steel car over the wooden type are quite clearly defined.

Note.—The cars represented in the above table were taken at random and represent a fair average of those in service under their respective classes. Those of the Algoma Central and Duluth & Iron Range represent the most compact modern types of steel hopper cars, but on account of the extremely short wheel base, concentrating the load on a short span, the limit of their operations must be confined to the roads for which they were constructed.



SCHOEN GONDOLA CAR FOR THE PITTSBURGH, BESSEMER & LAKE ERIE RAILROAD.

We are indebted to Mr. E. H. Utley, general manager of the Bessemer & Lake Erie Railroad, for these valuable drawings, and to Mr. Charles L. Taylor for assistance in securing information.

The study of this subject in collecting this information has led to similar treatment of the problem on another railroad, which will be presented in another issue.

Inasmuch as the amount of current required for exciting the field magnets of an electric motor is only a small fraction of the total current taken by the motor, the efficiency of the method of varying speed by field control is very high and is practically the same at minimum and maximum speeds; the relatively small amount of current handled permits of the use of a very small controller and renders it very easy to arrange for a large number of different running speeds.

A test of a 300 h. p. horizontal engine in England with superheated steam, produced under the improved Schmidt system of superheating, has shown a figure of 9 lbs. of steam per horse power hour. The temperature at the superheater was 800 deg. F.

DRIVING PLANERS.

THE VARIABLE POWER REQUIRED, AS REVEALED BY THE INDIVIDUAL MOTOR DRIVE.

BY J. C. STEEN.

If the individual driving of planers by electric motors had no other advantage than that of enabling its performance to be investigated from the standpoint of power consumed throughout the complete cycle of its movements, that alone would be of great value. In a certain large and well-equipped machine shop there is an individual motor-driven planer which presents in an interesting manner the characteristic features of the driving of an ordinary planer.

The motor which drives the planer is belted to the countershaft in the usual manner and operates at a constant speed. The planer, which was a 60-in. x 18-ft. machine, was made by a prominent machine tool builder, has four cutting heads and is spur-gear driven. An ammeter was permanently connected in the motor supply circuit and showed at all times the quantity of energy being used. At the time of the observations noted below, the machine was at work planing a block of forged steel about 20-ins. long, one tool cutting only. The capacity of the ammeter limited its indications to 100 amperes; beyond that point there was a stop pin.

The diagram presented in the engraving shows graphically, as nearly as was possible to reproduce it, the varying quantity of power input required during a cycle of cutting and reversal movement of the work. At the moment of the reverse from the cutting to the return stroke, the pointer on ammeter went hard against the stop pin, rebounding slightly each time, thus preventing correct reading at this period. The extreme amount at that period is here assumed as 120 amperes, which is undoubtedly somewhat low.

Reference to the diagram will show that during the cut (between points A and B) from 10 to 20 amperes were used, the average being about 15. At the time of reverse from cut to return, 120 (assumed) amperes were used; during the return motion this dropped to 40 amperes. At the time of the reverse from return to cut, 80 amperes were required, which quickly dropped to 10 amperes at the beginning of the cut.

From this data we have the following:

Power required to reverse from cut to return = 40.2 H.P.
Average power required during return stroke = 22 H. P.
Power required at reverse from return to cut = 26.8 H. P.
Average power required during cutting stroke = 5 H.P.

From this it may be seen that at the instant of reversal of the platen from the cutting to the return stroke, a surge of power equal to eight times that required for the cut was demanded.

The machine was working at a rate of six strokes per minute, and the amount of metal removed per minute was 2 cu. ins. Ten amperes being the lowest amount required during the cutting stroke it is assumed that the power required to move the platen, countershaft, pulleys, belts, etc. = 3.35 h. p. and the power required to remove the metal = 1.65 h. p., or .825 h. p per cu. in.

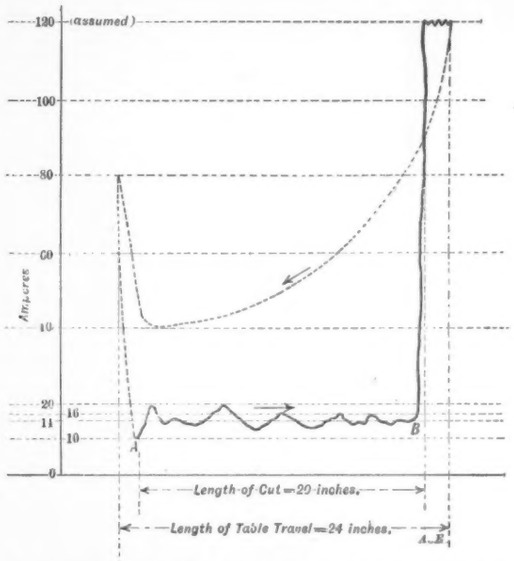


DIAGRAM SHOWING CURRENT REQUIRED DURING A COMPLETE CYCLE OF THE PLANER'S MOVEMENTS.

While this figure agrees very closely with one which is used by a certain electrical engineer for estimating purposes, it is of value only for similar conditions, as to metal, shape of tool, depth of cut, and amount of feed. The power necessary to move the platen alone could, of course, have been more closely obtained had time allowed.

The conditions noted are about the worst under which the machine could be operated, from an economical standpoint. These conditions are that of the heavy platen worked at short stroke, which means poor lubrication and frequent reversals, and only one tool at a comparatively light cut. The average power required for operating this machine under the conditions noted = 11.6 h. p. If the power cost per horse-power-hour be taken as unity, and 120 cu. ins. of metal were removed per hour, then 10.3 cu. ins. were removed for each unit of horse power cost.

Could this same cut have been taken at the full length of platen travel, the average horse power would probably not have been over 8.1 h. p. This would correspond to the removal of nearly 15 cu. ins. per unit of power cost. Again, could the four tools have been at work under the same conditions of material, cut, etc., the average power used would have been about 11.5 h. p., but the metal removed would have been four times as great, or 480 cu. ins. per hour—at the rate of 41.7 cu. ins. per unit of power cost. While these figures are not exact, they are sufficiently close for approximate comparison.

A train of 25 English cars was required to carry the 125 in. Bement-Miles crankshaft lathe recently shipped over the Manchester Ship Canal Company's tracks, on its way to the Manchester works of the Westinghouse Electrical & Manufacturing Company. This interesting fact was noted recently in the *American Machinist*, in an illustrated description. The lathe has a bed 64 ft. long and will swing pieces 45 ft. long.

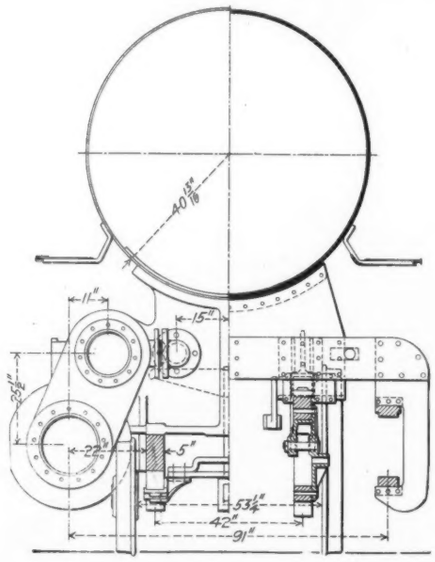
TANDEM COMPOUND FREIGHT LOCOMOTIVE.

2—8—0 TYPE.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

As a result of favorable experience with the experimental locomotive of this type, illustrated in these pages last month, the Schenectady Works of the American Locomotive Company have delivered a number of more powerful locomotives of the same type, which are the most powerful ever used on this road. This class is known as "G-4" and the tractive effort is 47,500 lbs., which gives them the rating of 47.570 on a basis of 100,000 lbs. as 100 per cent. The experimental design was rated at 39 per cent. The new class has 4,116 sq. ft. of heating surface, a figure which is exceeded by only four locomotives in our record. This surface is obtained with a 77-in. boiler and tubes 14 ft. 9 ins. long.

The cylinders are 16 and 30 by 30 ins. Both cylinders have piston valves, which are exactly alike. By using crossed

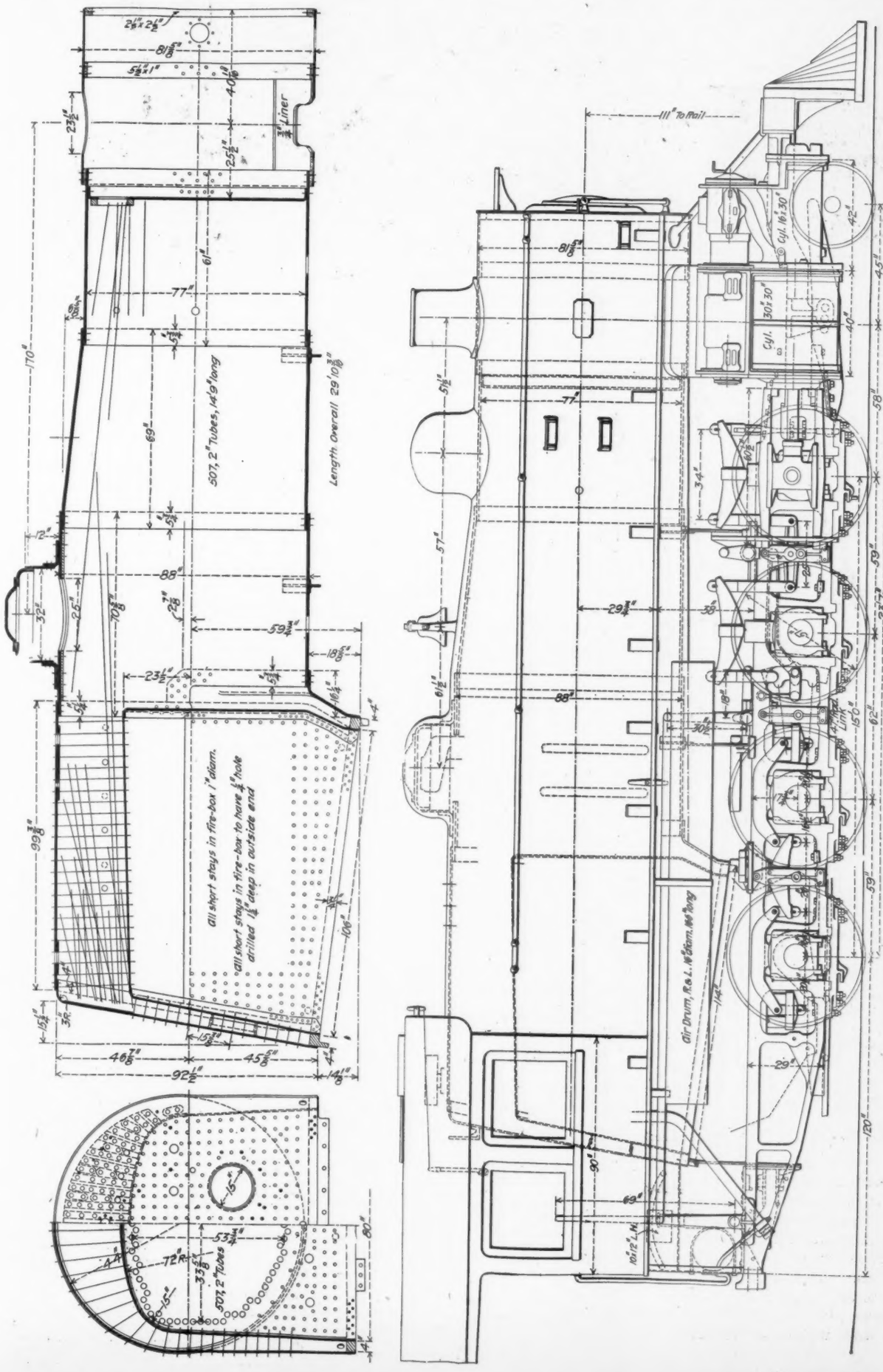


CROSS SECTION.—TANDEM-COMPOUND FREIGHT LOCOMOTIVE. NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

ports for the high pressure cylinders the high pressure valve gives inside admission and the low pressure valve gives outside admission. This construction and the arrangement of the cylinders closely resemble the first Schenectady tandem compound for the Northern Pacific (AMERICAN ENGINEER, September, 1901, page 271). For packing the piston rod between the cylinders a brass floating bushing is used as before, but in this case it has water grooves and is lubricated from the cab. To take out the low pressure packing rings the high pressure piston is removed by a clamp, the back head of the low pressure cylinder is loosened, the vertical portion of the guide yoke is unbolted from the horizontal portion and the guides come away with the head and the yoke without disturbing the alignment of the guides. It is now customary on this road to provide all new locomotives with cylinder bushings. This is done for the high pressure cylinders in this case, but not for the low pressure, because of their large diameter. The arrangement of the valves and cylinders on one side of the engine is as shown on page 276 of this journal for September, 1901.

The frames are very heavy, being 5 ins. wide throughout their length. They are of cast steel, having forked back ends for the front portions. At the cylinders these have a section of 5 by 10 ins. In large engines thimble pedestal binders are giving place to the older form of straps. In this case cast steel is used and the straps have toes 2 ins. deep.

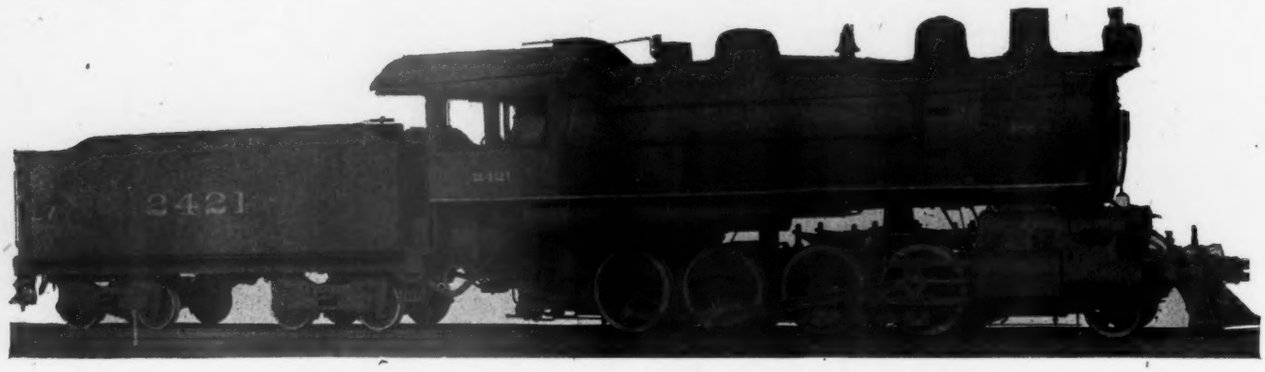
This boiler is the largest ever used on this road. It has a



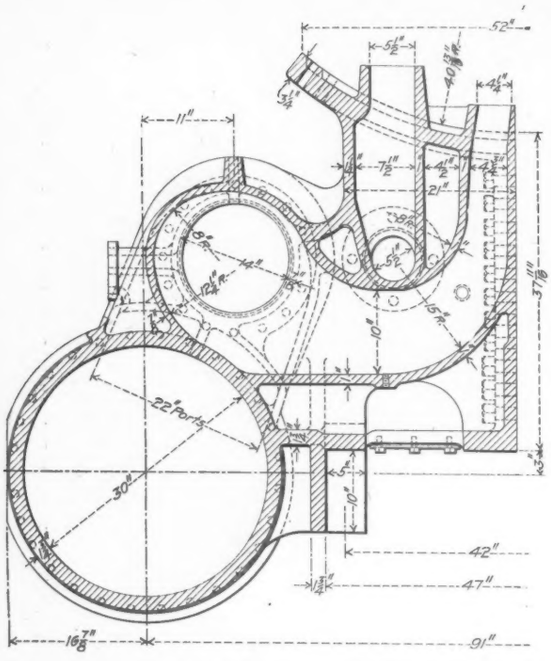
TANDEM COMPOUND FREIGHT LOCOMOTIVE.—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

2—8—0 Type.

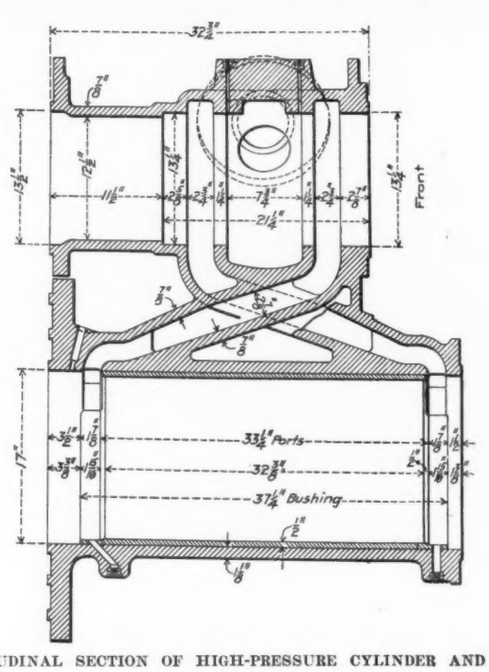
American Locomotive Company, Schenectady Works, *Builders.*



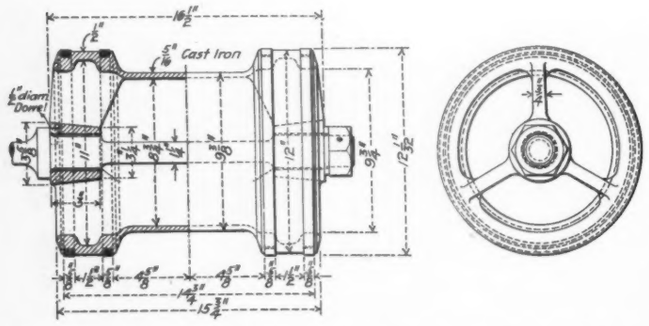
TANDEM-COMPOUND FREIGHT LOCOMOTIVE.—2-8-0 TYPE.
NEW YORK CENTRAL & HUDSON RIVER RAILROAD.
AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY WORKS, *Builders.*



CROSS SECTION OF LOW-PRESSURE CYLINDER AND VALVE.



LONGITUDINAL SECTION OF HIGH-PRESSURE CYLINDER AND VALVE, SHOWING CROSSED PORTS.



PISTON VALVE, USED FOR BOTH HIGH AND LOW PRESSURE CYLINDERS.

curved crown sheet and a steam space of 23 ins. over the crown sheet, which is liberal for so large a boiler. The front end is short and has no cinder pocket. In order to obtain a good attachment for the cylinders the smokebox has two 5½ by 1 in. rings, one at the tube sheet and the other at the extension joint. Two 16 by 166 in. main reservoirs furnish a large air storage capacity.

The following ratios and list of dimensions furnish means for comparisons with other engines:

RATIOS.

Heating surface to volume of high-pressure cylinders	= 591.4
Tractive weight to heating surface	= 48.6
Tractive weight to tractive effort	= 4.2
Tractive effort to heating surface	= 11.5
Heating surface to grate area	= 70.9
Tractive effort × diameter of drivers to heating surface	= 588.6
Heating surface to tractive effort	= 8.6%
Total weight to heating surface	= 54.7

TANDEM COMPOUND FREIGHT LOCOMOTIVE.

2—8—0 Type.

New York Central & Hudson River Railroad.

General Dimensions.

Gauge	4 ft. 8½ ins.
Fuel	Bituminous coal
Weight in working order	225,000 lbs.
Weight on drivers	200,000 lbs.
Weight engine and tender in working order	360,500 lbs.
Wheel base, driving	15 ft.
Wheel base, rigid	15 ft.
Wheel base, total	23 ft. 5 ins.
Wheel base, total, engine and tender	59 ft. 3 ins.

Cylinders.

Diameter of cylinders	16 and 30 ins.
Stroke of piston	30 ins.
Horizontal thickness of piston	5½ ins.
Diameter of piston rod	h. p., 3 ins.; l. p., 4 ins.
Kind of piston-rod packing	Gibbs vibrating cup

Valves.

Kind of slide valves	Piston type
Greatest travel of slide valves	6 ins.
Outside lap of slide valves	⅞ in.
Inside clearance of slide valves	H. p., 0 in.; l. p., ¼ in.
Lead of valves in full gear:	Line and line F. & B. ¼ in. lead at half stroke

Wheels, Etc.

Number of driving wheels	8
Diameter of driving wheels outside of tire	51 ins.
Material of driving wheels, centers	Cast steel
Thickness of tire	3½ ins.
Diameter and length of driving journals:	Main, 10 ins.; others, 9½ x 12 ins.

Diameter and length of main crankpin journals	7 ins. diameter x 7 ins.
Diameter and length of side-rod crankpin journals: Front, 5 x 4 ins.; back, 5 x 4¼ ins; inter., 5½ ins. diam. x 5 ins.	
Engine truck, kind	Two-wheel, swing bolster
Engine truck, journals	6¼ ins. diameter x 10 ins.
Diameter of engine truck wheels	30 ins.
Kind of engine truck wheels	Krupp steel tire

Boiler.

Style	Extended wagon top
Outside diameter of first ring	77 ins.
Working pressure	210 lbs.
Thickness of plates in barrel and outside of firebox: 13-16, 15-16, 9-16, 1, ¾, ⅝ and ⅞ in.	
Firebox, length	105 ins.
Firebox, width	79¼ ins.
Firebox, depth	Front, 82 ins.; back, 65 ins.
Firebox plates, thickness: Sides, 5-16 in.; back, ⅜ in.; crown, ⅜ in.; tube sheet, 9-16 in.	
Firebox, water space	4 ins. front, 4 ins. sides, 4 ins. back
Firebox, crown staying	Radial stays screw through crown and shell except 6 center rows to have button heads under crown and 3 front transverse rows expansion stays
Firebox, staybolts	Taylor iron, 1 in. diameter, 4-in. centers
Tubes, number	507
Tubes, diameter	2 ins.
Tubes, length over tube sheets	14 ft. 9 ins.
Firebrick, supported on	Tubes
Heating surface, tubes	3 889.3 sq. ft.
Heating surface, water tubes	26 sq. ft.
Heating surface, firebox	201.2 sq. ft.
Heating surface, total	4,116.5 sq. ft.
Grate surface	58 sq. ft.
Ashpan, style	Hopper, sectional
Exhaust pipes	Single, low
Exhaust nozzles	5, 5¼, and 5⅝ ins. diameter
Smokestack, inside diameter	20 ins.
Smokestack, top above rail	14 ft. 10 ins.
Boiler supplied by	Monitor injector No. 11

Tender.

Style	Water bottom
Weight empty	(Est.) 51,500 lbs.
Wheels, number	8
Wheels, diameter	33 ins.
Journals, diameter and length	5½ ins. diameter x 10 ins.
Wheel base	20 ft. 3 ins.
Tender frame	10-in. steel channels
Tender trucks	Two-wheel, center bearing, Fox pressed steel bolsters
Water capacity	7,000 U. S. gals.
Coal capacity	12 tons

WHAT MOTIVE POWER OFFICERS ARE THINKING ABOUT.

EDITORIAL CORRESPONDENCE.

The draughting-room is becoming an index of the character of a motive power organization. By a visit to the draughting-room one may form a correct opinion not only as to the kind of men in charge of the department, but of the probability of their advancement. The contrasts in draughting-rooms are becoming more striking, and, in fact, impressive.

A large road, which in the past has been noted as progressive, is now found to have a draughting-room filled with men some of whom have been there for many years, who have worked at the same tables, doing the same kind of work, accompanied by a sprinkling of youngsters from the shop. The room is in a dirty place, next to a roundhouse, with an ash-pit on one side and coal chutes on the other. The room is crowded, poorly lighted, unventilated, littered with old drawings and generally slovenly. The presence of the old men indicates that the draughting-room is a pocket in which the faithful draughtsman is allowed to remain until he becomes unambitious. The presence of the boys from the shop is a good feature, but in this instance it seems to give the impression of a desire to run the room cheaply, there are so many of them.

This draughting-room was not always in this condition, and that it has been allowed to drift indicates a lack of appreciation on the part of the department officers of one of the most useful and profitable tools given to their hands to use. The draughting-room cannot possibly be what it should be under any such conditions. Instead of being an important part of the brains of the department, it seems to be considered a necessary evil, and those who are condemned to its imprisonment are to be pitied.

These comments are suggested by conversation between the visitor and the men in the leisure of the noon hour. The subjects of the railway clubs and technical press were mentioned. The draughtsmen showed little interest in either, which led the visitor to remark that if they would read a good technical paper and follow the work of the railway clubs they might perhaps obtain advancement. It would be perfectly safe to make a rule to discharge draughtsmen or foremen who do not familiarize themselves, through a technical paper and the railroad clubs, with general progress in their line of work.

A very pleasing contrast was found on another and much smaller road, where the draughting-room was large, bright, clean and orderly, and full of earnest, interested and bright-looking young men. It was, in fact, a busy workshop, telling of the pride of the officers of the road in an efficient working department. It is evidently considered as a channel through which the men may pass into other branches, and is not allowed to become an ambition-killing pocket. It is easy to predict a bright and growing future, not only for the young men in this draughting-room, but for the superior officers of the department, who are broad-minded enough to make the draughting-room contribute to their success.

It is hoped that those to whom these paragraphs may apply will read them. It is also hoped that discouraged draughtsmen will read them. The draughting-room is one of the best schools of experience to be had on a railroad, but it is not a place in which a good man should stay until he is old. It is not difficult to get out of the draughting-room if a man shows by his work as a draughtsman his ability to carry executive responsibilities. Good foremen are always in demand, and this should be noted by the draughtsman who has executive ability.

Electric distribution of power is a feature of every plan for extending railroad shop plants and of every new plant. The progress of the last five years in this direction has been phenomenal. In all cases the plans for power houses provide for extension when the demand for power shall increase beyond a reasonable overload for the equipment which is installed. But there is danger of providing too little space for this purpose. The convenience of electric driving is such as to lead to unexpected extensions, and while going to the expense of erecting a power house, a larger provision for the future should be made. In the case of the shop improvements on the Chicago & Northwestern Railway, completed about two years ago, the power house was made large enough for an increase of 100 per cent., and now the only available space remaining is that which will soon be required for another air compressor. A new Allis-Chalmers cross-compound vertical engine is now nearly ready for service. It is direct-coupled to a 500-kw. General Electric generator furnishing 2,000 amperes at 250 volts. The engine has 22 and 36 x 42-in. cylinders and operates non-condensing. An engine of this character gives a power house a business-like appearance; and that a capacity of 500 kw. is needed is an indication of the possibilities of the growth of electric power distribution.

When constructing a power house of large capacity, the steam and electrical engineering problems become interesting, and an opportunity is offered for the application of good business and engineering judgment. This constitutes a new field on steam railways and a new opportunity is offered for young men who are thoroughly informed on electric and steam engineering questions. Railroad shops are nearly always located near large cities in order to secure a good labor market. Railroads always have a large amount of lighting at such points, and they are beginning to appreciate the opportunities for extending their central power station functions to include station and yard, as well as shop lighting. In several places plants of this kind are being worked out.

In several of the older shops visited bolt and even forging machines were found in small buildings at some considerable distance from the machine or blacksmith shops, and in one case this machinery was placed in a corner of the erecting shop. This location was selected because the space was available, and without thought of the fact that convenience to the stock of supplies and easy supervision are important for such work. While such locations may sometimes be justified, this sort of thing is typical of the old school of railroad shop management, in which commercial questions were not given sufficient attention. Such mistakes are not made in successful commercial establishments, and they are fortunately becoming less frequent in railroad shops.

MACHINE TOOL PROGRESS.

FEEDS AND DRIVES.

V.

BY C. W. OBERT.

The most extensive use of the positive-drive variable-speed mechanism has been made by the Bickford Drill and Tool Company, Cincinnati, Ohio, who have utilized it not only for the feeds but also for the main drives of their Bickford radial drills. The manifest advantages of the gear-drive mechanism over the cone-pulley-and-belt method of driving offer strong inducements to its use on main drives and it has proved very successful in this application.

The main drive of the Bickford drill is through two independent change gear mechanisms, one at the base of the column, X, and the other, Y, at the rear of the arm, as shown in Figs. 22 and 24, and also in Fig. 21. The main speed box, X, receives power on pulley, P, and delivers to a vertical shaft within the column. The vertical shaft drives back gear box Y through gears at the top of the column and a splined shaft extending down along the rear to permit vertical adjustments of the arm; from the back gear mechanism the drill spindle is driven direct.

Figs. 22 and 23 present an external and a sectional view of the main speed box, X. Power is received on pulley P of the device, which is keyed to the driving shaft S, Fig. 23. Upon this shaft S is keyed the four gears, A, B, C and D, of varying sizes, and each one of these gears meshes with a corresponding gear running loose on the driven shaft, T, as shown at E, F, G and K. The four different speeds available through these combinations are obtained by throwing one of the clutches, M or N, in the proper direction, which is accomplished by the handle L.

The proper direction in which to throw handle, L, is indicated on the upper side of the gear case (see Fig. 22), at the opening through which the handle projects. This opening is shaped like a letter "H" laid sideways, and each of its four corners or slots are numbered in succession from 1 to 4, as shown in Fig. 22. The lever L is capable of being swung in two directions, so that it may be set over into line with either pair of slots, 1 and 2 or 3 and 4, and then may be thrown into either slot of that pair.

The lever L is arranged to positively operate a different clutch for either pair of slots in the "H." Thus, when in either slot 1 or 2, clutch N is actuated and clutch M is locked in a central position; when handle L is in slots 3 or 4, clutch M is in use and N is locked out of clutch.

Four speeds are also available from the back gear box, Y. This device consists of a three-shaft change-gear arrangement in which two double-throw clutches are operated by the handles, Q and R, Figs. 21 and 24. This device is similar in principle to the four-speed change gear mechanism described

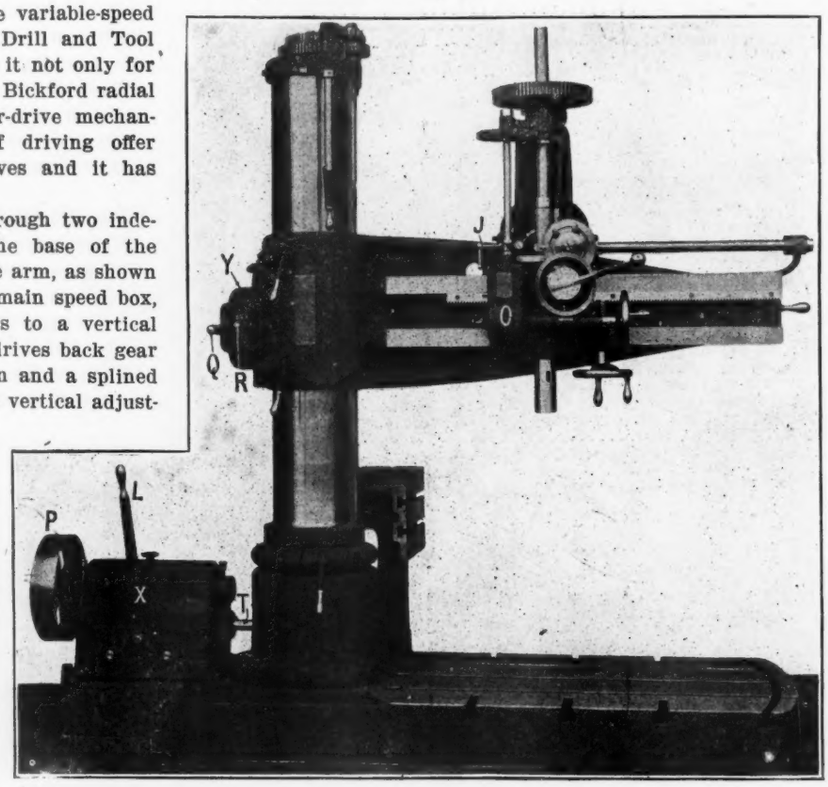


FIG. 21.—THE BICKFORD RADIAL DRILL. EQUIPPED WITH VARIABLE-SPEED GEARED DRIVE AND FEED.
THE BICKFORD DRILL AND TOOL COMPANY.

on page 143 (Fig. 18) of the preceding article of this series, which mechanism was, we are informed, suggested by the speed box used by the Bickford Company, who were the first to make use of this type of mechanism. Friction clutches are used in this device to permit clutching and disengagement without noise or shock while the machine is running. It is arranged so that each speed transmits to the spindle more than double the pulling power of the next faster speed.

These two devices thus afford a possible variation of sixteen

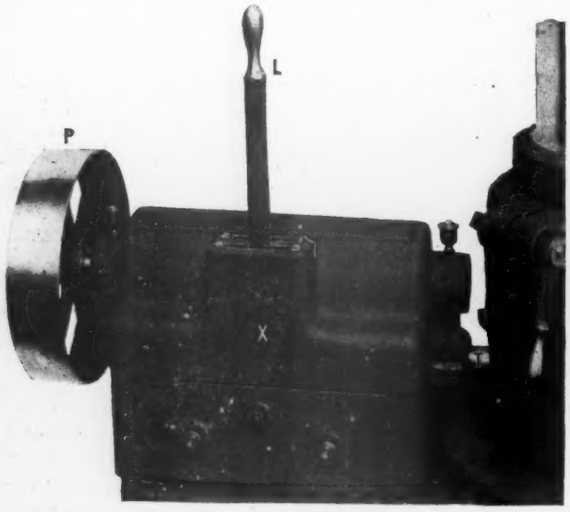


FIG. 22.—VIEW OF THE MAIN DRIVE SPEED BOX, SHOWING THE "H" SLOT ARRANGEMENT FOR CONTROLLING THE FOUR CLUTCHES WITH ONE LEVER.

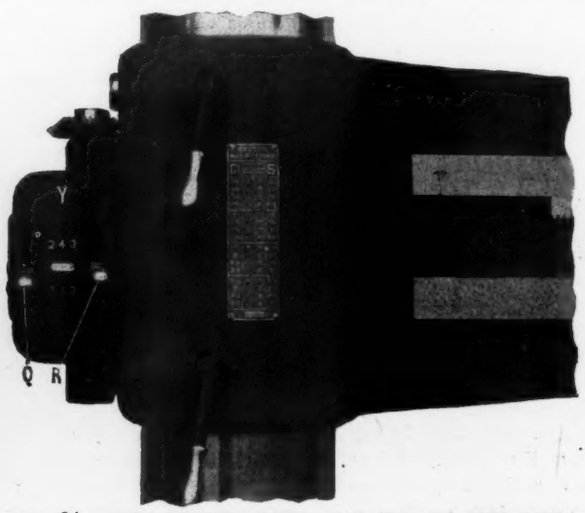


FIG. 24.—VIEW OF THE BACK GEAR BOX ON THE ARM. THIS MECHANISM IS DRIVEN THROUGH A SPLINED SHAFT AT THE REAR OF THE COLUMN.

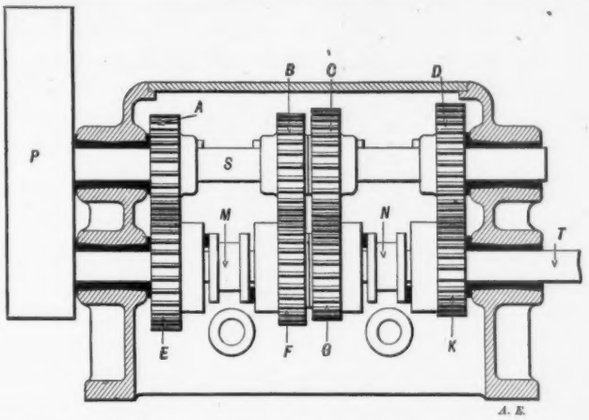


FIG. 23.—LONGITUDINAL SECTION OF THE MAIN DRIVE SPEED BOX.

different speeds, capable of easy and instantaneous changes, and attended with no interruption of power, as is necessary with belt changes. In this way, aside from the many other advantages, the gear-drive mechanism is far superior to the older cone pulley and belt method of driving.

The feed gear box for the drill spindle feeds is mounted on the head at the left of the spindle, as shown at O, Fig. 25, the interior arrangement of which box is shown in Fig. 26. This device consists of a series of loose gears—5, 6, 7 and 8, Fig. 26—which run loosely on shaft W, constantly in mesh with a nest of corresponding driving gears not shown. The method of changing speeds used here is shown at V; the driven shaft, W, has a "pull pin," U, inserted in a hole in its upper end, and a sliding key, V, is hinged to the end of pin U.

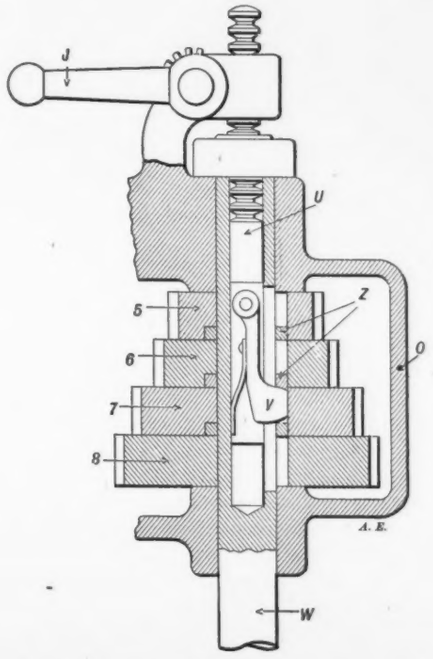


FIG. 26.—VERTICAL SECTION THROUGH THE FEED GEAR BOX SHOWING "PULL PIN" MECHANISM.

This key projects through a slot in the side of shaft W, so as to enter the keyways, of which there are three in the hub of each gear.

Between each of the gears there is a steel ring, Z, which serves to lift key V out and free it from any keyway when shifting to another speed, and then to direct it accurately into a keyway in the next gear as it comes around. The position of the lever, J, a quarter turn of which lever changes the feed to the next either higher or lower gear, indicates which of the gears is operating. This portion of the mechanism furnishes four different speeds, but this is supplemented by a two-speed device, operated by the pull-pin I, shown in Fig. 25, by means of which eight different speeds are made available. A feed-plate is placed upon the case of this feed box which indicates directly the spindle feed that will be obtained with each combination, the range being from .007 to .064 in. per revolution of the spindle.

These applications of the gear method of speed changing make the Bickford drill the most completely equipped for positive driving of any machine tool yet designed. The various devices here shown are praiseworthy for their sim-

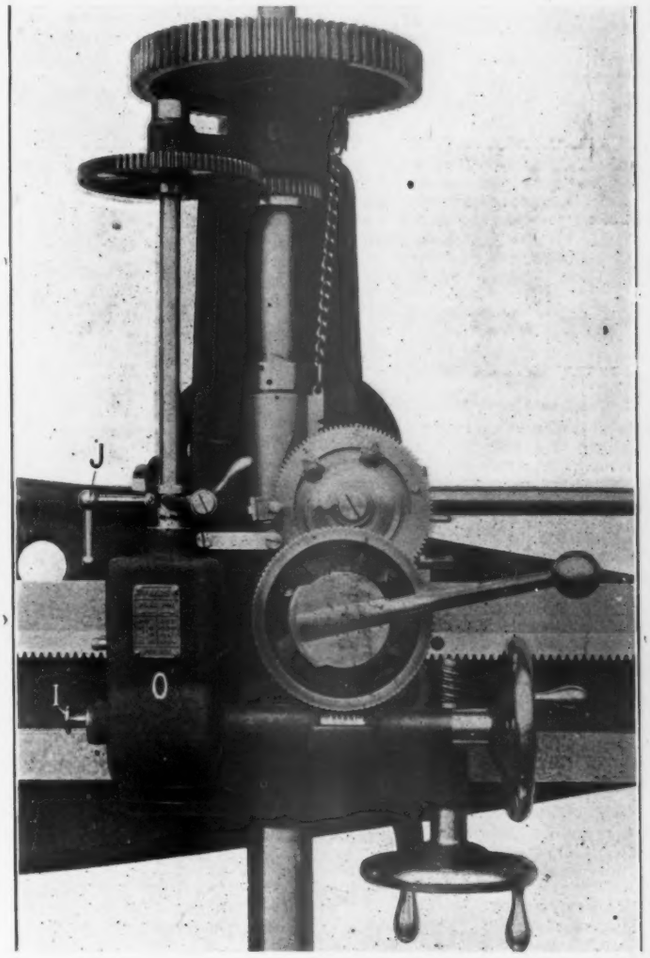


FIG. 25.—VIEW OF THE HEAD SHOWING ARRANGEMENT OF THE FEED GEAR BOX AT THE LEFT OF THE SPINDLE.

plicity and ingenious design, and are unrivaled for ease of manipulation. Steel gears have been found unnecessary with the ample design of parts that is used. The capacity of this drill with the positive drive and feeds is remarkable—a 1½-in. drill has been driven on this machine at a feed of .035 in. per revolution of the spindle through .45 carbon steel.

Mr. E. H. Harriman is truly one of the busiest men in Wall street, says a writer in the March *Cosmopolitan*, and it is only by the most careful system that he can attend to all of the duties that require his attention. On Thursdays he has about twenty committee meetings to attend. He has so subdivided the time that they succeed one another, at intervals of fifteen to thirty minutes, with the regularity of clockwork. In fact, they are cut short by the clock. In some cases, the performances go off with as much precision as a Punch-and-Judy show—the strings being pulled, as it were, by the power that dominates them. Extensive offices have been fitted up by Mr. Harriman on the fourth floor of one of the largest down town buildings, and the concourse of men passing in and out on Thursdays is an interesting sight.

(Established 1832.)

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY
BY
R. M. VAN ARSDALE,
J. S. BONSALL, Business Manager.

140 NASSAU STREET.....NEW YORK

G. M. BASFORD, Editor.

C. W. OBERT, Associate Editor.

MAY, 1903.

Subscription.—$2.00 *a year for the United States and Canada;* $2.50 *a year to Foreign Countries embraced in the Universal Postal Union.*

Remit by Express Money Order, Draft or Post Office Order.

Subscriptions for this paper will be received and copies kept for sale by the

Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St. S., Minneapolis, Minn.
Sampson Low, Marston & Co., Limited, St. Dunstan's House, Fetter Lane, E. C., London, England.

EDITORIAL ANNOUNCEMENTS.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.* **When a subscriber changes his address** *he ought to notify this office at once, so that the paper may be sent to the proper destination.*

CONTENTS.

ARTICLES ILLUSTRATED: Page

American Engineer Tests..... 162
Crane Beam and Slings, Designs..... 164
Individual Motor Driving, Applications to Old Machine Tools at the P. & L. E. R. R. Shops. R. V. Wright..... 165
Steel Cars on the Bessemer & Lake Erie Railroad..... 168
Driving Planers. The Variations of Power Required. By J. C. Steen..... 173
Locomotive, 2—8—0 Type, Tandem-Compound Freight, N. Y. C. & H. R..... 174
Machine Tool Progress, Feeds and Drives..... 178
Reading Shops, P. & R. Ry. The Power Plant..... 182
Collinwood Shops, L. S. & M. S. Ry. Group Driving of Tools 186
Seamless Boilers, Construction of, Ehrhardt Pressing Process 191
Spring Centering Device for Locomotive Trucks..... 192
Motor-Driven Machine Tools. Applications to Lathes..... 193
Metallic Truck, Four-Wheel, for Passenger Cars..... 197
Mica Metallic Packing..... 198
New Drilling Machine, Multiple Spindle for Mud Rings..... 201
New Axle Lathe, Extra Heavy..... 202
Washburn Double-Movement Tender and Pilot Coupler..... 202

ARTICLES NOT ILLUSTRATED:

Railway Shops. By R. H. Soule..... 161
What Motive-Power Officers Are Thinking About..... 177
German Locomotive Tests. By L. H. Fry..... 185
Oil Fuel Tests on Locomotives, Boston & Maine R. R..... 186
Locomotive Tests on Prussian State Railways. Report by Professor Von Borries..... 195
Locomotive Tests, Wide and Narrow Fireboxes and Compounding. A., T. & S. F..... 197
Liquid Fuel Burners..... 198
Blue Lead as a Pigment for Paints..... 198
Books and Pamphlets..... 199
Equipment and Manufacturing Notes..... 200
Safest Place in a Train..... 201

EDITORIALS:

Wanted—Results..... 180
Uniformity in Railroad Signaling..... 180
Fly-wheels on Planer Drives..... 181

CORRESPONDENCE:

The Special Apprentice..... 181
The Davis Counterbalance..... 181

WANTED—RESULTS.

Time was, and not so long ago, when all locomotives looked "alike," a car was a car, a machine tool was a machine tool, and all tool steels ran cool. The progress of years has brought comparatively few new fundamental principles of construction, but it has brought an infinite number of improvements in details in all these lines of mechanical development. To-day only the best will answer and the requirements are specialized so that every new addition to equipment is wanted for a definite and specific purpose. This is particularly true of motor driving and machine tools. Nowadays he who is not strictly up-to-date in selecting machinery is not likely to hold his position long, simply because he can not get what is wanted—*results.*

The engineers of the Interborough Rapid Transit Company of New York conducted tests of seven weeks' duration and spent several thousands in preparation for ordering the motor and control equipments for that road. They needed to know what they were doing and it was worth while. Nowadays the mechanical equipment of a new railroad shop costs from a quarter to half a million dollars or more, and such orders must necessarily be carefully placed.

Mechanical railroad men are studying motor driving and machine tools as never before. The best talent available is employed by the machine tool builders to meet and even anticipate the demands and it is the privilege of the technical journal to bring these factors into touch. This journal intends to meet the need and to exert its influence in the interests of advancement and improvement. The campaign now being conducted in these pages meets gratifying encouragement, particularly from the leaders in this improvement, and we shall endeavor to provide a meeting ground for those who know and those who want to know how to apply the best commercial practice to the railroad field.

Here is a three-sided problem. The railroad officer desires to improve his practice, the machine tool builder must supply special machinery for railroad requirements, the electrical people must know how railroad shops are operated. These three do not yet understand each other and only a railroad paper and a policy such as this journal has inaugurated can supply the educational advantages which the present situation requires.

UNIFORMITY IN RAILROAD SIGNALING.

With the increase in the intensity of traffic more and more dependence is placed upon signaling for the safe operation of trains. This fact is made clear by the outcries against "mere visual signals" whenever a collision occurs in a congested district which is supposed to be fully protected by signals. Automatic stops, to take the control of trains out of the hands of the engineers, are strongly advocated after such disasters, and the number of such devices is growing rapidly. The question is, whether the control of the train should be taken out of the hands of the engineer. This must be done if safety demands it, and we may yet come to the point of requiring apparatus of this kind. The public may some time demand automatic stops as they now demand automatic brakes, and if so the flexibility of train operation will be seriously impaired. The automatic stop does not appear to have been developed to a stage which entitles it to the confidence of signal engineers, and the difficulties are great enough to justify skepticism as to whether it ever will command confidence for use on steam roads. Let those interested in this device continue. They cannot fail to benefit the cause of signaling, and they may succeed. But there is much which may be done with present methods which will tend to render these stopping devices unnecessary.

Signaling needs to be made more uniform. Not only should the locations of signals and signaling practice in general be uniform, but the treatment of the application of signaling should indicate the true opinion of signals which is held by the officials of railroads. Locomotive engineers are largely

governed in their use of signals by the opinion of these officers as expressed by the methods used. For example, an engineer must necessarily have a small opinion of automatic block signals when he is governed by them for only a few miles out of an important terminal. Uniformity which takes the form of signaling the entire road is what is needed. Uniformity which is maintained without undue respect to a few dollars in first cost for locating signals where they can be seen without the necessity of carefully hunting for them is also greatly to be desired.

The development of signaling should be in the hands of men of wide experience who have sufficient authority to command respect of their opinions and who can make the most of what is now available. It is unfortunate that a department of operation of such importance has not made more progress in the strong current of advancement of the past ten years. The chief want is more signals, more uniformity in practice, and better discipline may then follow. The Railway Signal Association might perform an important service by establishing principles of good signaling as a guide for practice. This, thus far, has not been done.

FLY-WHEELS ON PLANER DRIVES.

It was with considerable surprise that we learned the attitude assumed by one of the most prominent machine tool builders in regard to the desirability of using flywheels upon the driving shafts of motor-driven planers. The fact that the fly-wheel as an auxiliary to the planer drive, as was fully discussed in the article on the motor-driven machine tools at the Collinwood shops of the L. S. & M. S. Railway, in our March, 1903, issue (page 102), was regarded by them as of questionable value, indicates a lack of investigation upon their part of the events attending the cycle of the planer's movements; in fact, it seems that little was known regarding the actual conditions met in driving planers until motor-driving methods came into use.

An interesting statement of the peculiar conditions met in driving planers is presented in an article, on page 174 of this issue, by Mr. J. C. Steen. The conditions actually met in all portions of the cycle of a large planer's movements have been traced by means of the current required by the motor driving it. The results, at least, indicate the fact that, in the absence of a flywheel upon the driving shaft, heavy surges of power are demanded at reversals of the platen, which in the case of motor driving, more particularly, should be avoided.

The tendencies of modern practice seem to indicate that the requirements of railroad repair shops can be most satisfactorily met by a judicious combination of the individual motor-drive and the group driving methods of operating the machine tools. The two principal problems to be met are a simple means of reducing the normal speed of the motor to drive the machine, and a successful method of readily changing the cutting speeds of the machines to suit the varying character of the work. Arrangements for reducing the speed from motor to machine by means of long belts with countershafts on platforms supported from the floor only, have proven unsatisfactory in every way; the noiseless chain belt is now being very extensively and successfully used for this purpose.

That the overlap is not necessary when distant signals are employed in automatic block signaling, was the opinion of twenty-two out of twenty-seven members of the Railway Signaling Club in an informal vote on this question taken at the recent annual meeting. This is an expression of superlative confidence in the discipline of our locomotive engineers. The writer believes that the overlap has not passed its usefulness. As long as appropriations for signals are so limited as to affect their proper application, as long as locomotive engineers must periodically explore the landscape for these signals because of lack of uniformity of location, and as long as these men are expected to haul 600-ton passenger trains at 60 miles per hour with 100-ton locomotives, and are called before their superiors for not making time, the overlap will be needed.

COMMUNICATIONS.

THE SPECIAL APPRENTICE.

To the Editors:

Your views of the special apprentice question are, to say the least, interesting, and, what is more important, they are very nearly right. The writer has probably less cause for complaint than the great majority of this class, as he has had splendid opportunities for getting experience in both car and locomotive work. A man arrives at a stage sooner or later, however, when he thinks that a little salary should be added to the large amount of experience which has constituted the principal part of his wages.

When the experience has made the man of some possible value to the railroad company, other people are generally able to see that he is capable of earning a little more money, and the chances are that the young man will be sorely tempted to go with some car or locomotive concern or into some other business for which he is partially fitted. Generally the railroad company does not come to the rescue with an offer of a definite position attached to living wages. He is told: "Remember the experience you are getting, my boy. You stand well with the company, and if you will 'plug along' for a while, you will be duly rewarded." No doubt the railroad company means well, and knows that we will be rewarded in the next world, or, at least, recognize their good intentions.

Special apprentices should not be promoted over the heads of old employees simply because they are "*supposed* to be specially well prepared for advancement" or because the "father is a great friend of the vice-president." The fact of the matter is, however, that a man of technical education and two or three years' experience is at least worth an ordinary mechanic's wages if he is at all worth retaining in the service.

"Q."

THE DAVIS COUNTERBALANCE.

To the Editors:

If ease of riding had been the only object sought in counterbalancing, the Master Mechanics' Association rules would be very different from what they are. In general, an engine can be made very faulty with any system of counterbalancing with revolving weights, if the features that are conducive to easy riding are bestowed too liberally upon the wheels. Riding qualities, moreover, depend upon so many other factors besides counterbalancing; the estimation of these qualities depends to such an extent upon the personal element, and a rational comparison of the two methods of counterbalancing is apparently so simple, that one cannot be fully satisfied unless he is shown why the Davis wheel is better than the wheels now in general use.

What is now greatly desired by all interested in counterbalancing is a demonstration founded on Newton's three laws of motion, in which the series of cause and effects is shown by logical steps so complete as to leave no room for questions between them, leading to the final effect on the engine. Does not the importance of the subject warrant Mr. C. E. Miller in *taking* time to indulge in a technical discussion of this?

Will Mr. Ira C. Hubbell explain *why* the system of forces which he describes yields the "distribution of weights necessary for a correctly counterbalanced wheel"?

How can revolving weights perfectly balance the forces of varying magnitude and direction which act on the crank pin in consequence of the motion of the reciprocating parts?

G. F. Starbuck.

To the Editors:

I have been much interested in the discussions of the Davis counterbalance in recent issues of The American Engineer, and wish to refer to the article on page 142 of your April number over the signature of Mr. Ira C. Hubbell.

Mr. Hubbell evidently overlooks the fact that the revolving weights on a locomotive driving wheel can be, as everyone admits, and actually are, perfectly balanced, and that it is the overbalance, or that which is *added* to counterbalance the reciprocating parts, that causes the blow on the rail. He has no more right to expect a resultant between one of his counterbalances of the Davis system and the crank than he would have to expect to isolate a part of the tire or one of the spokes and get a resultant between that and the counterbalance, because all of these—tire, rim, spokes, etc.—are revolving parts, and none are more perfectly balanced than are those weights which are commonly known as the "revolving parts"

of the driver. And none of these revolving parts are instrumental in causing the hammer blow of which Mr. Fetters speaks.

To determine this hammer blow we must take the excess balance alone, considering all the rest as part of a perfectly balanced wheel. Then it is readily seen that there can be only one resultant, and that it acts, as Mr. Fetters pointed out, between the two weights, directly opposite the crank, so that the same effect is obtained with twice the weight as with the single counterbalance.

ROBERT M. CAMPBELL.

To the Editors:

Will some one who is acquainted with the theory and merits of the Davis counterbalance answer the following questions with reference to the diagram given? Let us suppose that the diagram reproduced below represents a driving wheel:

First—Is there any objection to the *revolving parts* being balanced with a weight opposite the pin as shown at R; as the revolving parts do not cause the hammer blow if balanced?

Second—Will not one-half as much weight at R balance the

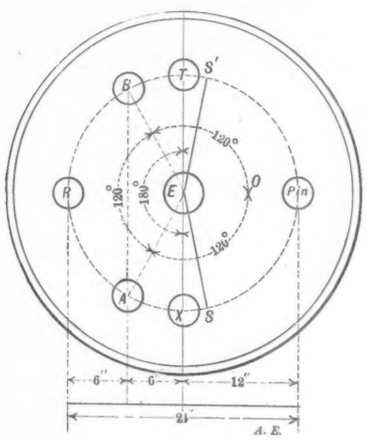


DIAGRAM OF LOCOMOTIVE DRIVING WHEEL.

revolving parts as it would take if weights are located at A and B, the 120° position?

Third—Is the balancing of the revolving parts with a weight at R unmechanical, mathematically incorrect or does it involve a waste of material?

Fourth—If the counterbalance weights are shifted out to the 180° position at X and T, and as suggested by Mr. Hubbell, give no hammer blow, is the wheel balanced? Is any portion of the reciprocating parts balanced? Will any addition or subtraction of an equal quantity of weight from X and T offset the balance?

Fifth—If the 120° or Davis location is correct and the weights are placed at A and B, have they not a resultant center of gravity which will fall half way between the center of the axle and the center of gravity of the weight R, as Mr. Fetters has outlined?

Sixth—Is not the real problem, in either the Davis method or Master Mechanics' method, to balance the *reciprocating parts* which exert a force which varies from nothing as the piston comes to rest at either end of the stroke to the maximum as the pin passes the top or bottom quarter, with fixed weights?

Seventh—Will fixed weights in rotation vary themselves to meet the conditions of the above problem by either system?

Eighth—Is it not a fallacy to assume that because a weight which is needed at R, under the one method, causes a hammer blow and that because two weights placed at X and T cause no hammer blow under the other method, as suggested by Mr. Hubbell, that weights placed midway between these points would both balance the *reciprocating parts* and do away with the hammer blow (remembering the increase in size needed in the Davis location in order to get a resultant equal to a weight at R, if the same proportion of reciprocating parts are to be used)?

Ninth—Is the "phenomenon" that a wheel can be balanced with weights 120° apart any greater discovery than that a fly-wheel can be built correctly with the spokes 120° apart—which is not a new discovery?

Tenth—Are there not some Davis balances so arranged that a portion of the weight comes in the 180° field *on the pin side of the wheel*, so that the edges of the counterbalance come about as the line S E S, to the pin? Is this either mathematical or mechanical?

X. Y. Z.

NEW LOCOMOTIVE SHOPS.

READING, PA.

PHILADELPHIA & READING RAILWAY.

V.

(For previous article see page 156.)

THE POWER PLANT.

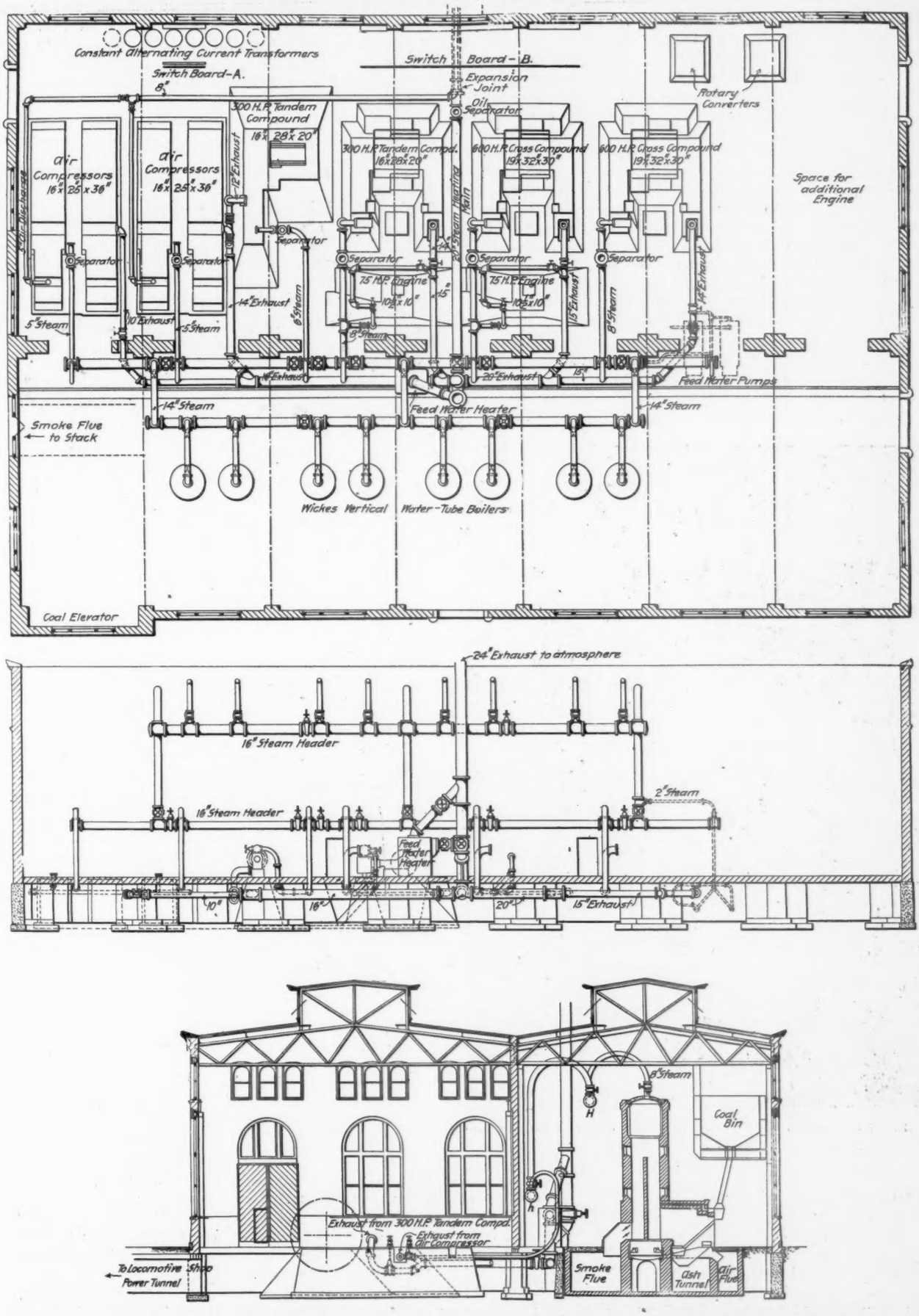
The growing importance of the part that the central power plant and the electrical method of distribution of power are playing in modern railroad repair shop installations is strikingly emphasized by the thorough and careful design and the character of the work of installation of the building and equipment of the power plant for the Reading shops. The plant that has been installed there is undoubtedly the most complete and well-equipped power plant that has ever been built for use in connection with railroad repair shop work. It is designed for a large ultimate capacity, and is intended to supply current for all classes of service—power and lighting, both arc and incandescent—to all of the departments of the railroad located at Reading. Besides supplying power and lighting for all departments of the locomotive repair shop, current will also be furnished to the car repair shops, which are located adjoining; to the depot buildings, roundhouses, freight yards; to a storehouse and to a repair plant within the city, and to a pumping station some distance outside of the city. In this way a great deal will depend upon the constancy of the service furnished by this plant, but the provisions made to prevent breakdowns are very elaborate and are not to be excelled in the very best modern power plant practice.

The power house is a substantial steel and brick building, 175 ft. long and 112 ft. wide inside, and with a clear vertical space inside of 35 ft. under the roof trusses. It is divided into two sections by a division wall, one the boiler room (50 ft. wide) on the east side and the engine room (62 ft. wide) on the west, the engine room having an 8 ft. 8 in. basement in which all the steam and exhaust piping for the engines is carried. The general arrangement of apparatus in the plant is indicated in the floor plan drawing on the opposite page, together with which is presented a cross section of the building. Two external views of the power house were presented on page 14 of our January (1903) issue, one from the west side and the other from the boiler-room side, showing the separate building for handling the ashes.

An important feature of the power plant building is the tile roof, providing the advantage of freedom from dripping moisture, inherent with all iron roofs in cold weather; also it is absolutely fireproof, there being no wood used. The roof is built up of hollow book tiles laid upon inverted T bars resting as purlins, upon the steel roof frame, and the whole is covered with slag cement. In fact, the entire building is equally as fireproof, no wood being used in any part of it except for doors and window casings.

The engine room is served by a 10-ton hand crane, all the steam piping being carried below the engine room floor to give free head-room. The crane was used very successfully from the completion of the building for installing all of the machinery. The lower portion of the engine room walls were laid to a height of 6 ft. above the floor with white tile-faced brick; this is found to very materially brighten up the room, reflecting light upon the machinery, as well as also to present a very pleasing appearance. The ventilator windows in the lantern upon the roof are opened and closed by hand control from the floor through chain and sprocket connections—a very convenient and quick method in case of a sudden storm.

The boiler room contains 8 Wickes vertical water tube boilers, set in batteries of two each, as indicated in the floor plan. Each boiler is of 250-h. p. (heating surface = 5,112 sq. ft.) capacity at the working pressure of 150 lbs. per sq. in., making



FLOOR PLAN AND CROSS SECTION OF BUILDING, AND SPECIAL SECTIONAL ELEVATION TO SHOW ARRANGEMENT OF STEAM PIPING.

READING SHOPS POWER PLANT.——PHILADELPHIA & READING RAILWAY.

S. F. Prince, Jr., *Superintendent Motive Power.* E. E. Brown, *Electrical Engineer.*

a total plant capacity of 2,000-h. p. The boilers are fired by the well-known Roney rocking-grate stokers, which were furnished by Westinghouse, Church, Kerr & Co. Each boiler has an effective grate area of 62½ sq. ft.

The stokers are operated by two small Westinghouse engines, the drives being so arranged that each engine operates only four stokers. Extension couplings are provided for the drive shafts, however, so that in case of shut-down at either engine the other can be arranged to drive all the stokers, for which either engine has sufficient capacity. Steam engine drives were preferred to electric motors for convenience in starting. Draft is furnished both by a chimney and by a fan on the forced-draft system, the requirements calling for both an air pressure below the grate and an exhaust above.

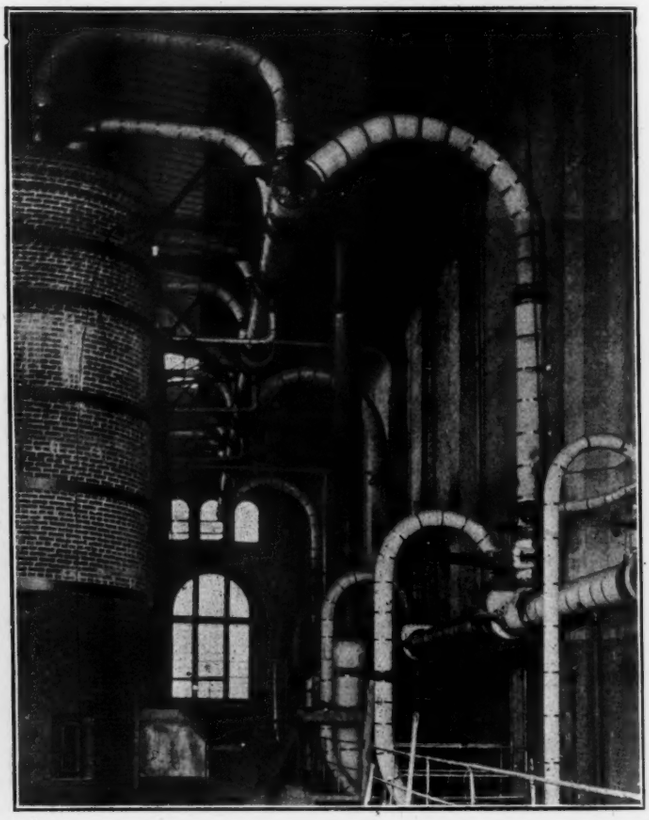
Natural draft is furnished by a very pretty brick stack, 125 ft. high, with an inside diameter of 10 ft. This stack was built to special design by the Alphons Custodis Chimney Construction Company, New York. The connection between the boilers and the chimney is had through an 8½ ft. by 9½ ft. underground smoke flue located at the rear of the boilers, as shown in the cross-section view of the power house. The undergrate forced draft is furnished by a 10-ft. blower fan, located at the north end of the boiler room and delivering through the underground air flue shown in front of the boilers.

VIEW IN FIRE ROOM, SHOWING THE WICKES VERTICAL BOILERS AND THE COAL CHUTES LEADING FROM THE ELEVATED COAL BUNKERS TO THE STOKERS.

Dampers are provided at each boiler to regulate the air pressure, as well as to regulate the effect of the natural draft.

The reason that both natural exhaust draft and forced draft are used is that both were required with the stoker as installed in order to obtain the desired working efficiency of 10.5 lbs. of water evaporated per pound of combustible. The specifications call for an exhaust suction above the grate which would produce a ⅛-in. difference of level in a U-tube, and a forced draft pressure below the grate sufficient to produce a difference of level of 1 in. in a U-tube. In a test that was made shortly after the boilers were placed into service, a performance was shown of 10.6 lbs. of water evaporated per pound of combustible with the regular coal, showing under analysis 19.6 per cent. of refuse and 2.14 per cent. of moisture, and with an exhaust draft above the grate of 7-32 in. (U-tube) and a forced draft below of 9-32-in. (U-tube), the steam pressure averaging only 140 lbs. and the boilers working under only an 87.4 per cent. rating.

Coal is stored in a series of elevated hopper bins, of 300



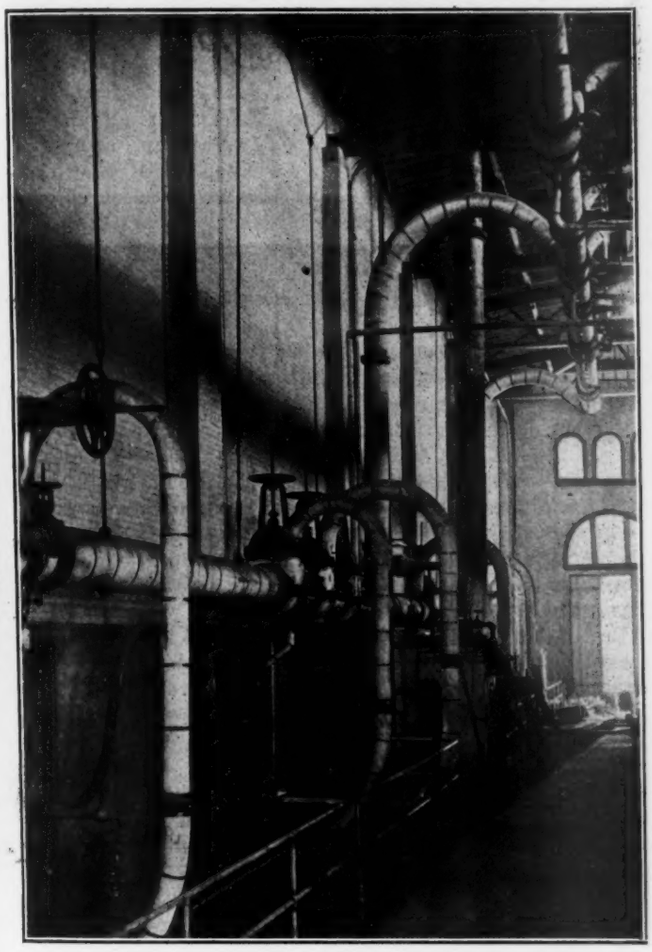
VIEW IN BOILER ROOM, SHOWING THE VERTICAL BOILERS AND THE RELATIVE LOCATIONS OF THE TWO 16-IN. STEAM HEADERS.

tons capacity, located above the fire room, from which it is delivered direct to the stokers by chutes, as shown in the cross section and also in the view of the boilers. The bins are of built-up steel construction and are supported partially from the side wall and partially from the roof trusses, which are extra heavy; this frees the fire room of obstructions. The coal is delivered into the bins by a conveyor system of a capacity of 100 tons per hour, which carries it from the receiving pit under the track at the east side of the building and distributes it, in connection with a scraper conveyor above the pockets, into any desired bin. The coal used is a buckwheat grade, containing about 20 per cent. of ash.

The ash conveyor system is entirely separate from that for the coal; it consists of a scraper line leading through the ash tunnel under the ash-dumping portions of the grates, and delivers underground into the separate ash storage building outside of the boiler room. In this ash building another elevator conveyor raises the ashes up into bins, from which they are dumped into cars for removal. The ash storage building involves an interesting construction; the bin floor slants at an angle of about 45 degrees toward the dumping, or track side, and is lined with 1-in. glass plate. This produces an absolutely non-corrosive surface, upon which the ashes slide with the utmost freedom.

The piping systems are undoubtedly the most complete and best arranged of any to be found in power plant practice. Two illustrations of the same are presented herewith to indicate the method of swing suspension of the steam headers to allow for all conditions of expansion and also to show the

partial duplicate arrangement of connections. Expansion is well cared for, being taken care of by the swing suspension and long-radius bends in all cases, except in the power tunnel, where it was found necessary to use slip joints. Duplication is almost wholly provided for by the two steam headers (marked H and h in the cross section), each of which headers are of three-quarters the size that would have been required if a single header had been used, thus ensuring ample receiver capacity. There are three 14-in. pipe connections between the two headers to permit cutting around any leak or disabled portion. Another valuable feature of the piping connections



VIEW OF STEAM PIPING SHOWING SWING METHOD OF SUSPENSION AND ARRANGEMENT OF LONG RADIUS BENDS TO MAKE CONNECTIONS ON UPPER SIDES OF HEADERS.

is that all leads from either header are taken from the top, so that no condensation is liable to be entrained but will tend to pocket in the header from which it is regularly drained.

The piping is an excellent example of steamfitting work, having been installed by the Best Manufacturing Company, Pittsburg, Pa. By-passes are included on all steam valves above 8 ins. in diameter. The live steam system is carefully arranged to avoid interruptions of service. Each boiler feeds from its steam drum directly into the upper 16-in. header, H, and the upper header delivers steam to the lower 16-in. header, h, through either one, or all, of three 14-in. connections with long-radius bends. The pumps, the engines and the air compressor take steam from the lower header through 5 and 8-in. pipes as required. An interesting feature of the installation was the assumption of a cost of the entire piping at $10 per boiler horse-power in the preliminary estimate—this figure proved to be very close, tending, however, a trifle low.

The boilers are fed by Janesville boiler-feed pumps, and are protected from high and low water by Reliance whistle alarms. The feed water is heated by a Cochrane 2,000-h.p. open exhaust steam heater, through which all the exhaust steam passes on its way to shop heating or to the atmosphere.

GERMAN LOCOMOTIVE TESTS.

BY LAWFORD H. FRY.

In the Journal of the Association of German Engineers (*Zeitschrift der Vereines Deutscher Ingenieure*) for November 22, 1902, Herr von Borries reports a most interesting series of tests made on the Prussian State Railway with the latest superheater engines and four-cylinder balanced compounds. Translated extracts from this report appear on page 195 of this issue and will be found interesting in more than one direction. Not only the figures obtained, but the thorough manner in which the results are presented, deserve attention. It will be seen that in determining the horse-power developed by the locomotives, the resistance of the locomotive and tender, and the resistance of the train are calculated separately by independent formulæ and then added together to obtain the total tractive power required. This appears to be a most logical procedure and it is interesting to compare the results thus obtained with those obtained by the method usually employed in this country. The figures below show the results of comparing the Barbier formulæ, which Herr von Borries uses, with those of *Engineering News* and of the Baldwin Locomotive Works, which find general acceptance here. The formulæ, R being the resistance in pounds per ton (2,000 lbs.) and V the speed in miles per hour, are as follows:

Engineering News..... $R = 2 + \frac{V}{4}$

Baldwin Locomotive Works ..... $R = 3 + \frac{V}{6}$

Barbier (Locomotive and Tender).... $R = 7.6 + 4.6\,V\frac{V + 20}{1000}$

Barbier (Train)..... $R = 3.2 + 1.55\,V\frac{V + 31}{1000}$

The resistance in pounds per ton for various speeds which are given by these formulæ are shown in the following table:

Speed in Miles per Hour.	Resistance in Pounds per Ton. Engineering News.	Baldwin Loco. Works.	V. Borries (Loco. and Tender).	V. Borries (Train).
10	4.50	4.67	8.98	3.84
20	7.00	6.33	11.28	4.78
30	9.50	8.00	14.35	6.03
40	12.00	9.67	18.61	7.60
50	14.50	11.33	23.70	9.48
60	17.00	13.00	29.65	11.66
70	19.50	14.67	36.58	14.16
80	22.00	17.33	44.40	16.96
90	24.50	18.00	53.14	20.08
100	27.00	19.67	62.80	23.50

It will be observed that while the German locomotive resistances are very considerably higher than the American figures, yet the car resistances are lower at all speeds below 80 miles per hour, above which speeds the application of the formulæ is somewhat problematical. Presumably the German figures are intended to give the *indicated* tractive power required—that is, the tractive power which must be developed in the cylinders to overcome the resistance of the machinery of the engine in addition to the rolling resistance, while the American formulæ are intended to give the required *available* tractive power—that is, the tractive power required at the rails to move the train exclusive of the power required to move the locomotive and machinery.

Another noteworthy point is the limit which Herr von Borries sets for the rates of evaporation and combustion, which are:

Maximum evaporation—14.5 lbs. of water per square foot of heating surface per hour.

Maximum combustion—97 pounds of coal per square foot of grate area per hour.

If these figures are compared with Professor Goss's tests of the Purdue locomotive it will be seen that while the maximum evaporation is about the same in both cases, the rate of fuel consumption in the Purdue boiler was carried to about 180

lbs. per square foot of grate per hour, or nearly double the amount which Herr von Borries takes as the maximum rate for the German engines. Of course, the more rapid American combustion corresponds to a higher smoke-box vacuum and a smaller amount of water evaporated per pound of coal.

OIL FUEL TESTS ON LOCOMOTIVES.

BOSTON & MAINE RAILROAD.

Descriptions of the application of oil fuel to pushing locomotives used at the Hoosac Tunnel on the Boston & Maine were published in this journal in June, 1902, page 185; August, page 233, and September, page 273.

Because of the impossibility of securing satisfactory data in tests at the tunnel, where trains are usually handled by two locomotives, one burning coal and the other oil, the tests for comparative consumption of coal and oil were made on the western section of the Fitchburg division, between September 17 and November 29 of last year. The oil burner made 38 trips between Mechanicville and East Deerfield, 85 miles, and the coal burner made 23 trips with the same trains and schedules. At the prices prevailing at the time oil was more expensive than coal and its use will probably not be extended beyond the present special service at the tunnel. The locomotives were exactly alike, except as to the arrangements for burning oil or coal, and have the following dimensions:

Type, 2—8—0; simple engines, cylinders, 20 x 24 ins.; driving wheels, 57 ins.; weight on drivers, 121,000 lbs.; total weight, 141,000 lbs.; weight of tender, 80,000 lbs.; total weight of locomotive and tender, 221,000 lbs.; firebox, 41¼ x 102 ins.; tubes, length 11 ft. 6 ins., diameter 2 ins., number 285; boiler diameter, 64 ins.; total heating surface, 1,856 sq. ft.; grate area, 29.6 sq. ft.; steam pressure, 200 lbs. per square inch. The diameter of the exhaust nozzle was 4¼ ins. with coal and 4¾ ins. with oil.

Special attention is directed to the large number of trips with each engine. This was an important test, from which the future policy of this road with respect to oil fuel was determined. It was therefore carefully conducted. Train No. 298 is scheduled between Mechanicville and East Deerfield, 85 miles, at 28 miles per hour with no stops. Train No. 207 is scheduled between the same stations in the opposite direction at 13 miles per hour, running time, with one stop, this being in the direction of the heavy grade. The tunnel was included in both cases and the results were not complicated by the use of helpers through the tunnel. Mr. Henry Bartlett, superintendent of motive power, has kindly supplied this information and has included the comparison of the cost of oil and fuel with the prices prevailing at the time of the tests.

COMPARISON OF OIL AND COAL FUEL.

Boston & Maine Railroad.

	Oil.	Coal.
Engine numbers	1068	1074
Train numbers	207, 298	207, 298
Trips	38	23
Cars hauled	1,079	626
Average cars hauled per trip	28.39	27.22
Tons hauled	30,481	17,982
Average tons hauled per trip	802.13	781.83
Engine miles	3,230	1 955
Average engine miles per trip	85	85
Car miles	91,715	53,210
Average car miles per trip	2,413.55	2,313.48
Ton miles	2 590,885	1,528,470
Average ton miles per trip	68,181.18	66,455.22
Gallons oil consumed	33,700	.....
Average gallons oil consumed per trip	886.84	.....
Pounds consumed	260 164	295,075
Average pounds consumed per trip	6.846.42	12,829.35
Average pounds consumed per engine mile	80.55	150.93
Average pounds consumed per car mile	2.84	5.55
Average pounds consumed per ton mile	.100	.193
Cost	$1,011.00	$458.56
Average cost per trip	26.61	19.94
Average cost per engine mile	.3130	.2346
Average cost per car mile	.01102	.00862
Average cost per ton mile	.00039	.00030

Gallon of oil weighs 7.72 lbs.
Cost of oil, 3 cents per gallon.
Cost of coal, $3.45 per ton (2,220 lbs.).
Oil test—September 17 to October 11, 1902.
Coal test, November 10 to November 29, 1902.
Test between Mechanicville and East Deerfield.

NEW LOCOMOTIVE AND CAR SHOPS.

COLLINWOOD, OHIO.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

VIII.

GROUP DRIVING OF TOOLS IN THE MACHINE SHOP.

As stated in the fifth article of this series, about five-eighths of the total number of machine tools in the locomotive repair department shops at Collinwood are driven in groups from short, isolated sections of line shafting, each group having its line shaft driven by a separate constant-speed motor. The group driven tools are divided up into 17 groups of varying sizes and arrangement, according to convenience; the distribution of the groups has largely been a result of the lay-out of the tools, but it also gives evidence of an attempt to departmentize certain classes of work, such as the rod work, or the motion work, for instance. The actual arrangement of the group driven tools is indicated in the list of tools and motors for the Collinwood shops, which appeared upon pages 42 and 43 of the February (1903) issue of this journal, in which list was given not only the types and sizes of tools included in each group, but also the total power that may be required for each tool and the capacity of the driving motor that was installed to carry the aggregate load from each group.

As before stated, group driving was deemed advisable and was given the preference in the problem of powering the machine tools at the Collinwood shops. Only where important and valid reasons ruled otherwise were the tools arranged for individual drives, among which were when the tools were located under crane runways, where overhead belts and countershafts would interfere with crane service; where the advantages to be gained from the variable speeds afforded by individual driving were of sufficient weight; or where the tools are isolated, as in the boiler shop, so that the long stretches of shafting necessary would be inconvenient and wasteful of power, etc. The great majority of the tools were arranged for the group driving, including the smaller lathes, the milling machines, shapers, drill presses, turret lathes and other rapid duplicating machinery, etc.

An important feature of the group drives in this installation is that all the line shafts are driven from their motors by high-speed "silent" sprocket chains. All of the group drives in th locomotive shop, excepting the flue machinery group, are equipped with the Renold silent chain, made by the Link-Belt Engineering Company, Philadelphia, Pa.; the drive for the group of machines in the flue department, as well as for the group drives in the bolt and spring shops and for the coal conveyor, is made through the Morse rocker-joint silent chain, furnished by the Morse Chain Company, Trumansburg, N. Y. The blower and exhauster fans in the smith shops are driven by Renold chains.

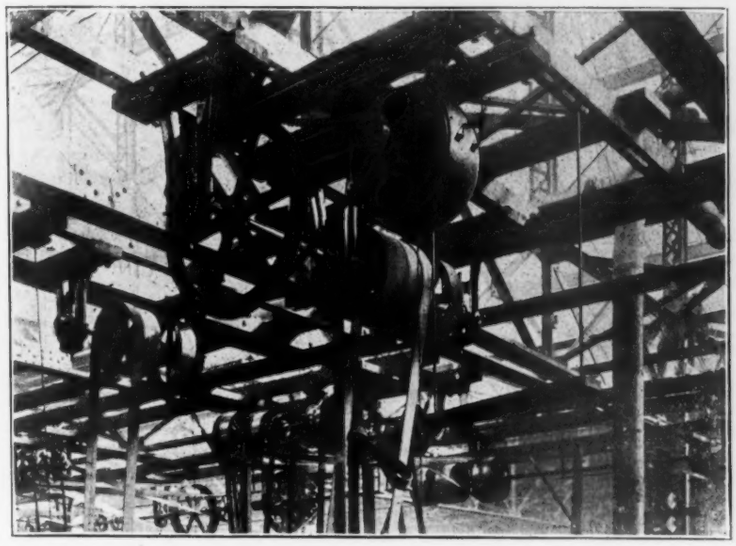
The most remarkable features of these drives are the comparatively high speed at which the chains are run, and also the closeness of centers at which the sprockets for the chains are set. The chains are in all cases operated at speeds of from 1,100 to 1,200 ft. per minute, and their sprocket-wheel centers are in most cases spaced 30 ins. apart; in the flue department group and in the blacksmith shop drives the sprocket centers are spaced slightly farther apart for convenience.

The great advantages of the chain drive are the positiveness of drive, which characterizes gear driving, and the possibility of running at high speeds without the disagreeable noise attending gear drives or drives using the ordinary sprocket chain when operated at high speeds; thus all the advantages of gear driving are retained and the advantage of much greater flexibility added.

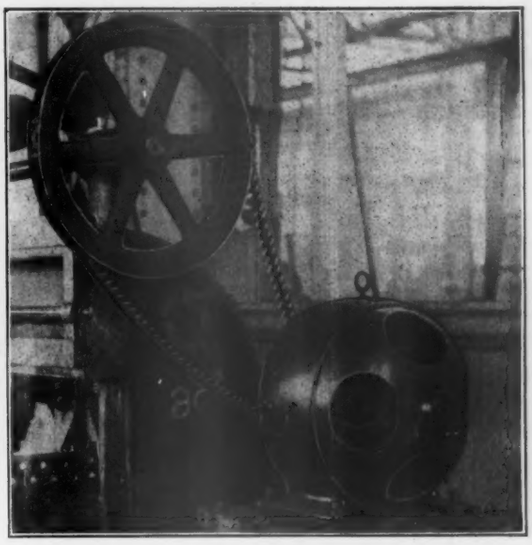
As is well known, the silent chain consists of stamped links or bars of steel pivoted together into a multiple chain. The Renold chain uses a shouldered solid stud for pivoting, while the Morse chain builds up the links upon frictionless rocker-joint pivots. Besides permitting high speeds without excessive

noise, these chains do not require the sprockets to be set at fixed distances or short centers. They run with a smooth action and are not affected by wear or stretching, as the chain merely rides higher upon the sprocket teeth after stretching. Excessive journal friction is absolutely avoided, as these chains are always run slack. They are also not affected by excessive heat or by dampness.

The engravings, presented below, illustrate typical chain drives, one presenting a view of one of the ceiling-constant-speed motors driving a line shaft in the machine shop, and the other a chain drive for a machine tool, in both of which cases the Renold chain is used. The close spacing between centers of sprocket wheels is made very noticeable in these drives.



TYPICAL ARRANGEMENT OF CEILING MOTOR FOR GROUP DRIVING. LIGHT TOOL SECTION OF MACHINE SHOP.



VIEW OF A CHAIN DRIVE UPON A MACHINE TOOL. RENOLD "SILENT" CHAIN.

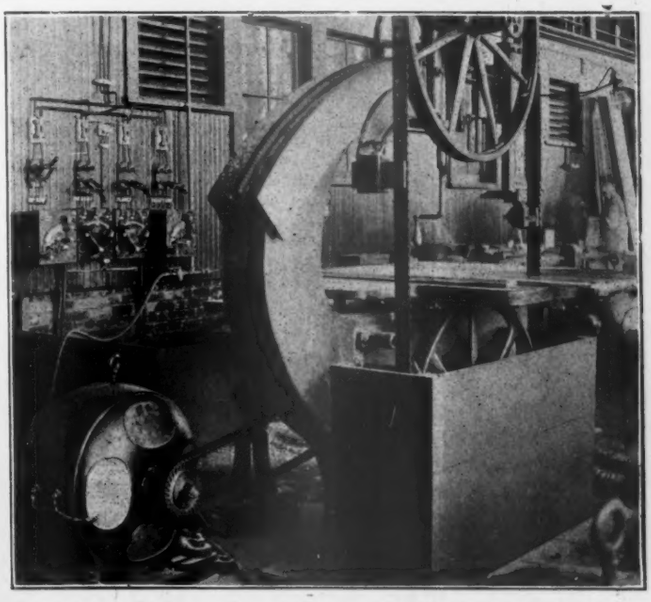
The further illustrations presented below show applications of chain driving to the drives of wood-working machinery located in the tender department of the boiler shop. One is that of a drive for a band saw, while the other is for a table saw, both being driven through Morse rocker-joint chains. These chains are running at high speeds, open and exposed to dust and dirt, and are giving excellent results.

The drawing reproduced in the engraving upon page 188, indicates an interesting arrangement of the motor and the manner of supporting it, for the group-drive in the bolt shop, in the blacksmith shop building. In this case the line shaft, as well as the motor support, are located upon a side wall. The motor is supported by a very substantial bracket, built up of structural shapes and steel plate as indicated and attached to the wall by substantial through bolts passing through and bearing upon angles at the opposite side in order to distribute the pressure. The motor is located at the outer end of the bracket and drives the initial portion of the line shaft by a Morse silent chain, as shown.

The line shaft passes behind the motor, running in the floor-stand and wall bearings shown, and from it the bolt header below the motor bracket (an Ajax bolt header) is driven. The machines beyond require a slower speed, the reduction for which is obtained by a geared connection involving a pinion on the initial shaft driving a gear on the further shaft.

CHAIN DRIVE FOR A SAW IN THE TENDER DEPARTMENT OF THE BOILER SHOP. MORSE ROCKER-JOINT CHAIN.

The line shaft for each of the group-drives in the machine shop is driven at a speed of 150 revolutions per minute. The line shaft for the flue machinery is operated at 175 revolutions per minute, while those in the blacksmith shop are driven at higher speeds, from 200 to 450 revolutions per minute, as required. The countershaft speeds, of course, vary, being in all cases adapted to the machine driven. In the machine shop

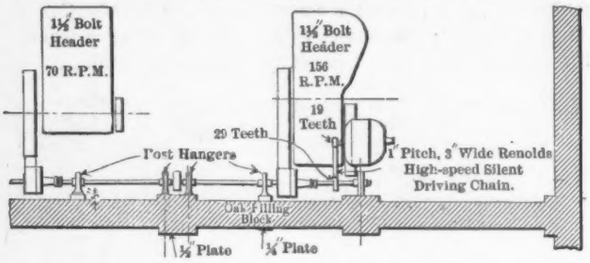


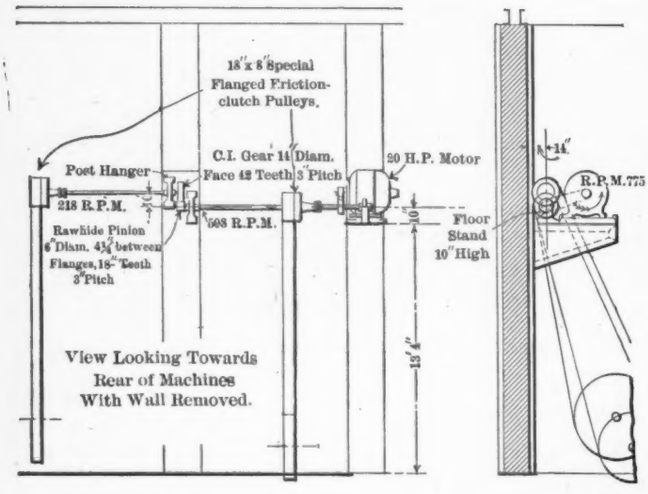
CHAIN DRIVE FOR A BAND SAW IN THE BOILER SHOP. MORSE ROCKER-JOINT CHAIN.

groups the speed reduction in the drive from the motor to the line shaft is about 6 to 1; in the various other groups it varies according to the machines driven.

An important feature of the construction of the light tool section of the machine shop, which was indicated in the drawing on page 369 of the December, 1902, issue, is the arrangement of the lower roof trusses with intermediate cross mem-

bers to accommodate the countershafting supports. The lower trusses are divided up into panels approximately 11 ft. square, so that all countershafting supports used in the machine shop are of the same length, irrespective of which direction they run; this greatly facilitated the getting out of the counter-




18"x 8" Special Flanged Friction-clutch Pulleys.
Post Hanger
C.I. Gear 14" Diam. Face 42 Teeth 3 Pitch
20 H.P. Motor
218 R.P.M.
508 R.P.M.
Rawhide Pinion 6" Diam. 4¼" between Flanges, 18" Teeth 3" Pitch
14"
R.P.M. 775
Floor Stand 10" High
View Looking Towards Rear of Machines With Wall Removed.
13¼"

A. E.

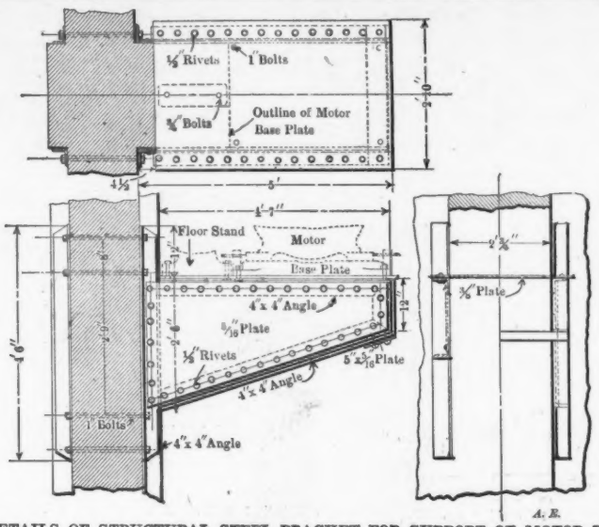
ARRANGEMENT OF A GROUP DRIVE IN THE BOLT SHOP, SHOWING METHOD OF MOUNTING MOTOR UPON A SIDE-WALL BRACKET.

shafting supports, and furthermore makes them interchangeable in case of possible future alterations. In the heavy tool section, this intermediate truss work is, of course, omitted, as the crane service there prevents shafting being used.

MOTOR DRIVEN TOOLS IN THE MACHINE SHOP.

A few more representative examples of motor-drive applications to the machine tools in the machine shop are presented herewith. The machines shown here appear well chosen to indicate the sturdy and substantial character of the tools selected for the Collinwood equipment—the effort appears to have been, and rightly so, to obtain the greatest possible production by the use of the new high-speed tool steels and machine tools strong enough to "pull the heavy cuts," rather than to economize by the use of lighter or old tools. An instance of the saving effected in one direction by this policy is to be had in the increased number of driving tires which are now bored per day as compared with previous practice. Where formerly only about three tires were bored per day of ten hours, now with the new tool steel and the heavy boring mill from seven to eight tires are bored and finished complete per day, including time of placing on table, setting and removing.

The machine tool upon which the above operation is performed is one of the 84-in. Niles boring mills, with two heads, which is driven by a 10-h.p. multiple voltage motor. The tires in question were 56-in. Midvale driving tires, and the cut was taken at a cutting speed of 19 ft. per minute and at a feed of 3-16-in. per revolution of the table, the depth of cut varying with the tire. The tool steel used was the Styrian brand of air-hardening steel. When beginning boring, the roughing tool, carried by one of the two heads, is started first and run down with a heavy cut for about 1½ ins., after which the finishing tool, carried by the other head, is started in and the two are then operated together.

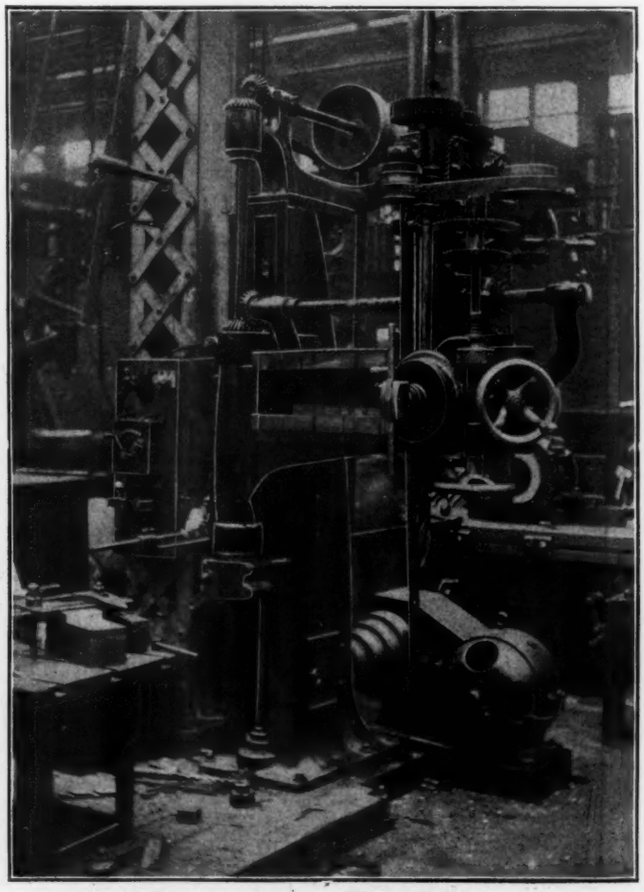


A. E.

DETAILS OF STRUCTURAL STEEL BRACKET FOR SUPPORT OF MOTOR IN BOLT SHOP GROUP DRIVE.

The illustration on page 189 presents a view of the 51-in. boring mill (tool No. 9 of the Collinwood tool list), which was furnished by the Niles Tool Works Company. The drive for this tool is from a 7½-h.p. Crocker-Wheeler multiple-voltage motor, through a gearing reduction, as shown at the rear of the machine. The circuit-breaker for the motor is located at the rear of the machine, so that in case it is opened the operator cannot lean over and throw it in. He has to walk some little distance—this is intended to call his attention to the fact that the main switch must be opened before the circuit-breaker is thrown in; it serves to remind him that he must not throw in the circuit-breaker without opening the switch.

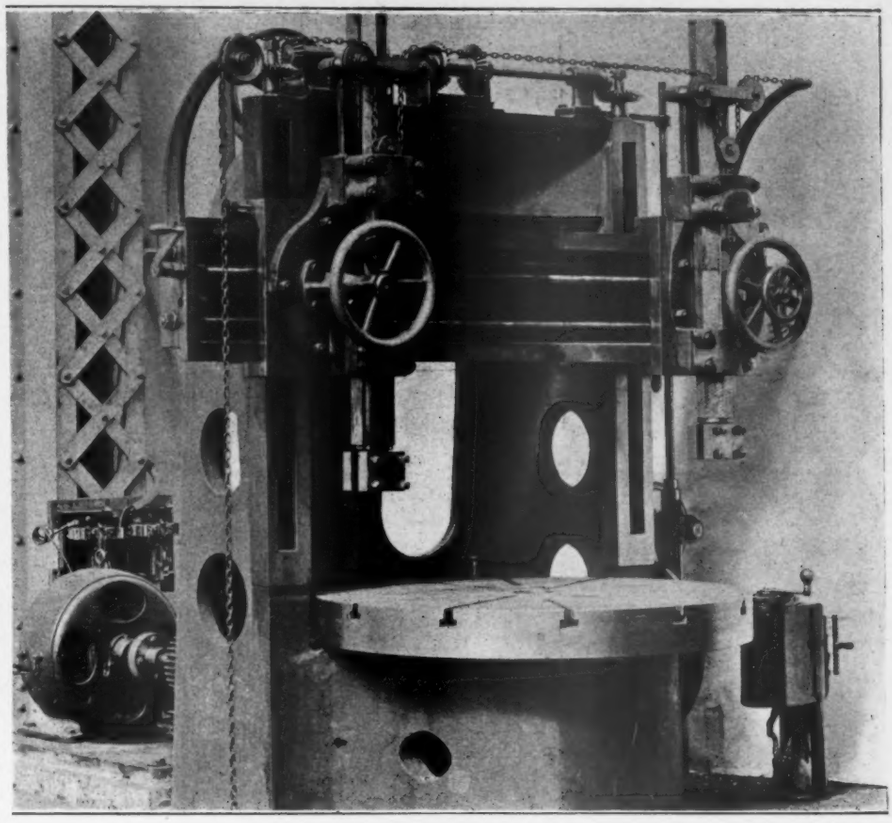
A number of tools were furnished for the equipment of



48-IN. RADIAL DRILL.—PRENTICE BROS. CO.
DRIVEN BY A 3-H.P. CONSTANT-SPEED CROCKER-WHEELER MOTOR.
COLLINWOOD SHOPS.—LAKE SHORE & MICHIGAN SOUTHERN RY.

these shops by Prentice Bros. Company, Worcester, Mass. One of them, a 48-in. electrically driven radial drill, is illustrated in the accompanying engraving, page 188. This machine (tool No. 42) is driven by a 3-h.p. constant-speed Crocker-Wheeler motor, which is connected to the cone shaft by two trains of gears running in opposite directions for reversal. These gears drive the cone shaft through friction clutches which are controlled by a lever from the front of the machine, so that by it the machine may be instantly stopped, started or reversed. The gears are heavy and well proportioned. Eight changes of speed are available at the drill spindle by means of the four-step cone pulleys and the back gears, and also geared variable-speed feeds are provided, furnishing eight changes of feed from .0057 to .0540 in. per revolution of the spindle.

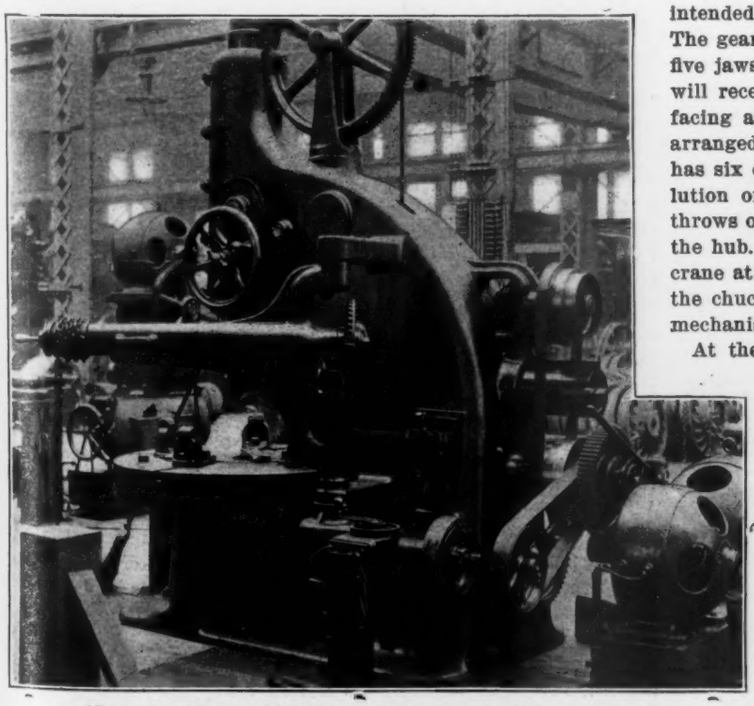
An important feature of this machine is the arrangement of the arm upon ball bearings, in order to swing easily, and also the vertical adjustment of the arm by power. The spindle of this machine has an improved quick return and stop motion, by which the point of the drill may be quickly moved down to the work and then thrown in on the power feed—all while the machine is in operation. The feed is automatically released when the spindle reaches its lowest position, preventing damage to the gears. Among the other machine tools furnished to the Collinwood machine shop by the Prentice Bros. Company, besides the above-mentioned drill, are a 30-in. swing drill, a 24-in. drill, a 21-in. drill, eight 21-in. swing engine lathes and nine 16-in. engine lathes, all of which were handled through their Cleveland selling agents, the Strong, Carlisle & Hammond Company.



51-IN. BORING MILL.—NILES TOOL WORKS CO.
DRIVEN BY A 7½-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.
COLLINWOOD SHOPS.—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

The machine illustrated below is the 48-in. car-wheel boring machine (tool No. 77), which was furnished by the Putnam Machine Company, Fitchburg, Mass. This machine is driven by a 7½-h.p. multiple-voltage motor, the controller for which is located at the right-hand side of the tool convenient to the operator.

This machine is from a new and extremely heavy design, intended to adapt it to the heavy duty self-hardening steels. The gearing is of ample strength throughout. The chuck has five jaws, operated either universally or independently, which will receive wheels from 15 to 48 ins. in diameter. The hub facing attachment is independent of the main spindle, being arranged to work automatically with the spindle. The spindle has six changes of feed, varying from 3-16 to ⅝ in. per revolution of the chuck, and also has an automatic stop which throws out the feed after the boring cutter has passed through the hub. An important feature of this machine is the power crane at the side of the machine for swinging wheels up onto the chuck; this is conveniently handled by a lever and speed mechanism at the front of the machine.



48-IN. CAR WHEEL BORING MACHINE.—PUTNAM MACHINE CO.
DRIVEN BY A 7½-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.
COLLINWOOD SHOPS.—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

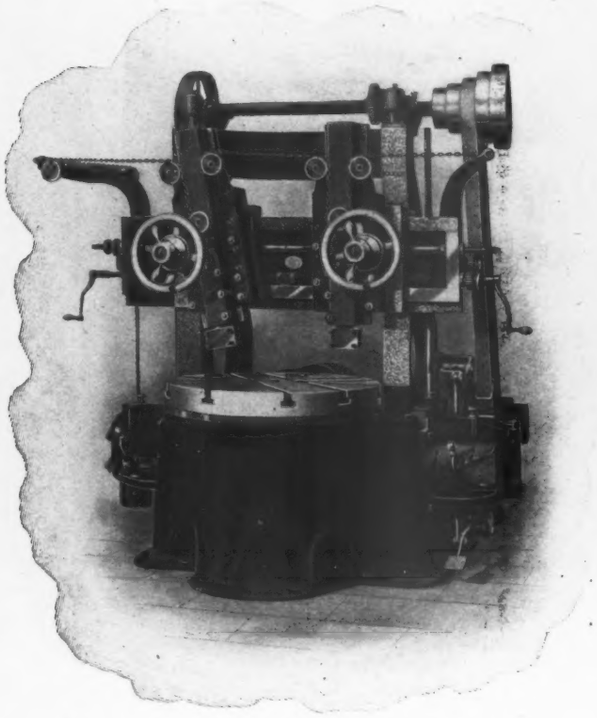
At the top of the following page is illustrated the 37-in. boring mill, two of which (tools Nos. 71 and 72) were furnished by the Bullard Machine Tool Company, Bridgeport, Conn. They are belt-driven by 5-h.p. constant-speed motors, the necessary speed changes being obtained by belt and five-step cone pulleys.

This machine has two swivel heads, which are entirely independent in their movements both as to direction and amount of feed. Either head can be set at any angle and can be brought to the center for boring. The feeds, which are positive gear-driven, have ten changes ranging from 1-32 to ¾-in. horizontally and from 1-50 to ½-in. in angular and vertical directions. The cross rail is raised or lowered by power.

The engraving on page 190 illustrates the 42-in.

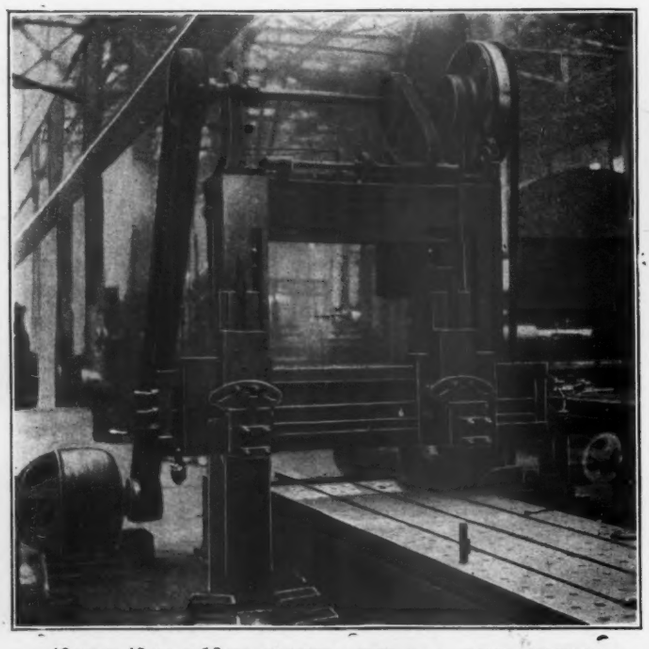
x 42-in. x 12 ft. motor-driven planer (tool No. 46) built by the G. A. Gray & Co., Cincinnati, O. It is driven by a 15-h.p. multiple-voltage motor, the motor operating the planer through a belted drive to the countershaft pulley; the arrangement shown is what is designated as the "motor-belted" type of drive by the G. A. Gray Company.

This planer has a table drive of the spur gear type, and is

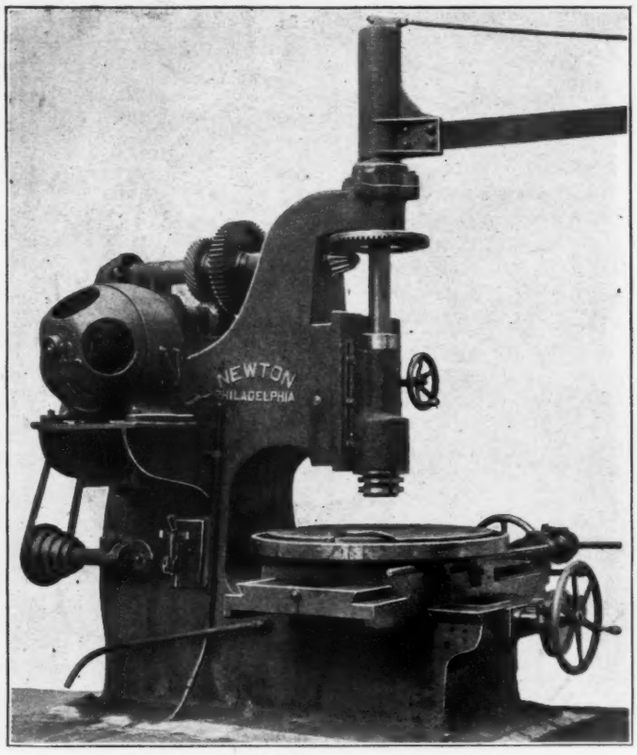


37-IN. BORING MILL.—BULLARD MACHINE TOOL CO.
DRIVEN BY A 5-H.P. CONSTANT-SPEED CROCKER-WHEELER MOTOR.

arranged for raising and lowering the cross rail by power. The table has two pairs of independent dogs, the extra pair on the rear side of the table, operating with an extra belt shifter lever; hinged to each shifter lever is a special trip which may be lifted when it is desired to run the table forward without disturbing the rear dog. In this way the work



42-IN. X 42-IN. X 12-FT. PLANER.—THE G. A. GRAY COMPANY.
DRIVEN BY A 15-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.



VERTICAL SPINDLE MILLING MACHINE.—NEWTON MACHINE TOOL CO.
DRIVEN BY A 10-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.

may be set and the cut started complete from either side of the planer.

The engraving above illustrates the No. 3 vertical spindle milling machine (tool No. 20) which was furnished by the Newton Machine Tool Company, Philadelphia, Pa. It is driven by a 10-h.p. multiple-voltage motor, the controller not being shown. An interesting motor support bracket is used upon this machine; it is of cast-iron bolted to the side of the machine's frame. The recess beneath the bracket furnishes a convenient receptacle for the resistance box used in connection with the motor control.

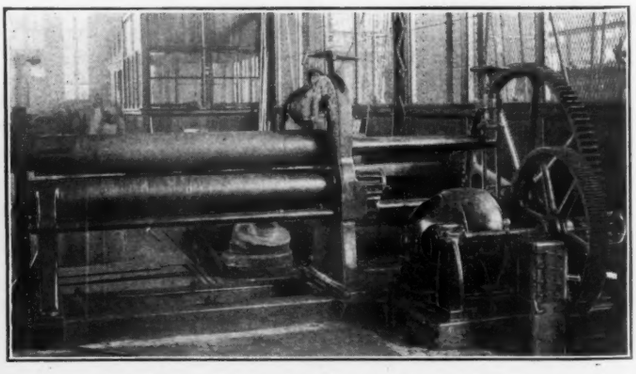


PLATE BENDING ROLL.—HILLES & JONES.
DRIVEN BY A 10-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.

The bending roll (tool No. 84), illustrated above, is the No. 2 plate roll made by Hilles & Jones, Wilmington, Del. It is driven by a 10 h. p. multiple-voltage Crocker-Wheeler motor through cut gears, as shown. The motor is mounted upon an extension of the bed, in front of which is located the controller.

This method of driving a bending roll is found very convenient, inasmuch as the rolls can so easily be reversed by the controller. The rolls are driven through steel pinions, and the back housing is hinged to permit removing plates after having been rolled to full circles.

THE CONSTRUCTION OF SEAMLESS BOILERS.

BY G. LENTZ, C. E., DÜSSELDORF, GERMANY.

At the recent Düsseldorf Exhibition, in the pavilion of the Rheinische Metallwaaren und Maschinen Fabrik, the products of the Ehrhardt hydraulic pressing process were exhibited. These works were established in 1889 by Mr. Ehrhardt, and now, with their supplemental works, employ more than 6,000 hands.

The Ehrhardt process, patented by the inventor in 1891, consists essentially in simultaneously punching and shaping metal blocks. To produce a hollow cylinder, a square piece of red-hot steel (a, Figs. 1 and 2) is placed in a matrix (b). The cross-section of the steel block, measured diagonally, corresponds to the diameter of the matrix. The latter is then closed by the lid d, serving as a guide for a mandrel (c), which is driven into the metal by means of a powerful hydraulic press. The diameter of the mandrel is chosen so that the material forced aside by it is exactly sufficient to fill the four segment-shaped spaces (e) between the square sides of the block and the interior surface of the matrix. Thus it is possible to work upon the minimum amount of metal necessary for the production of the piece under consideration.

If R be the radius of the matrix, the radius (r) of the mandrel is found by the formula:

$$\pi r^2 = \pi R^2 - 2R^2$$
$$r = 0.603R.$$

As the metal while being acted upon can give way at the sides, the mandrel enters the metal without great difficulty, and a hollow cylinder with closed bottom, as shown in Fig. 3, is produced; the bottom has naturally the shape of the head of the mandrel (c). This hollow body can be drawn out anew in order to produce tubes with thin walls. In the same way hollow bodies with square sections may be manufactured, which are punched in a corresponding matrix, the blocks constituting the inscribed circle of the rectangular section of the square to be produced. Blocks of irregular sections may be punched and shaped in quite the same way, there being, however, the necessary condition that the piece of metal be centered by the matrix, and that sufficient space be left for receiving the material pressed away by the mandrel. In pressing, such an amount of friction is produced against the walls of the matrix that the pressure of the mandrel on the block is proportionately small, and only a slight longitudinal compression of the material is effected.

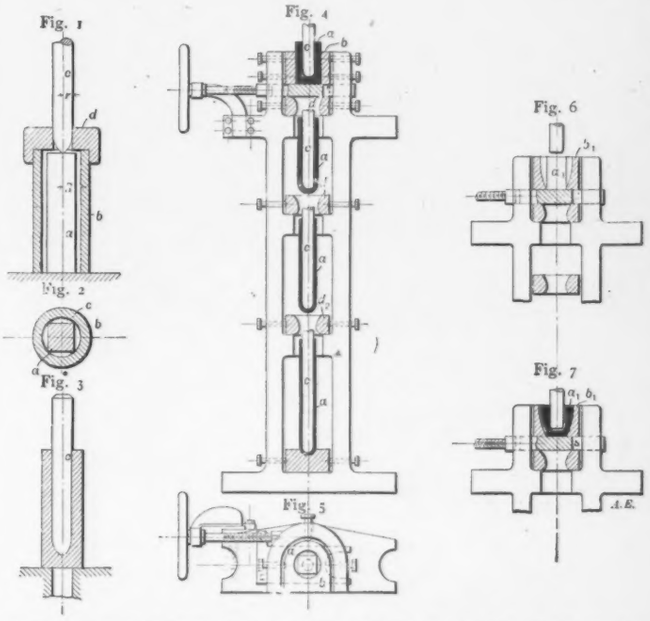
Figs. 4 to 7 illustrate apparatus for producing hollow tubular bodies, starting from a blank (a) of any shape. This blank is first punched by means of a mandrel (c) in a die (b) the bottom of which is formed by a slide (s) which is moved horizontally in the die by a screw-spindle and hand-wheel. After the metal blank in the die has been perforated as described, the slide s is withdrawn, the mandrel is moved downward together with the tubular body and presses together with the latter successively through the drawing rings d, d_1, d_2, until the tubular body has acquired the requisite thickness. The punching may also be effected by means of a short steel cylinder and a matrix of a special shape, wider at the top than at the bottom (Figs. 6 and 7).

The precision with which objects of determined dimensions are produced, and also the smoothness and polish of their surfaces, are remarkable. It is, for example, possible to make base-chamber shrapnels with walls only 2 mm. (0.0787 in.) thick, without the necessity of any machining inside.

In order to produce long weldless hollow bodies—tubes, for instance—the blank, after being perforated, is gripped by the pincers of a draw-bench and drawn out, during which operation the direction of movement remains the same. Thick tubes can thus be drawn out three times successively without it being necessary to heat the body after each operation. It is therefore possible with one heating only to produce a tube of great length.

When the thickness of the walls does not exceed 3.5 mm. (0.138 in.) the tubes are generally calibered by cold drawing on a solid bar. A red-hot temperature is very suitable for all these operations, and need not be exceeded. The perfection of the machinery at present employed allows the producing of weldless tubes with a precision of diameter or thickness of 0.1 mm. (0.0039 sq. in.). The mandrel being exactly centered and precisely guided, continues to advance without deviating when the movement has once been correctly started. The manufacture of steel flasks for highly compressed gases particularly serves to illustrate the valuable qualities of press work. These flasks, which are made in all sizes, are tested before being officially accepted, by a pressure test made as follows: The flask is filled with water and carefully weighed, then subjected to a pressure of at least 250 atmospheres. A steel band laid around the flask serves to determine the expansion resulting from this test. If it indicates no permanent deformation, the flask is accepted.

In consequence of the pressure operation the strength of



APPARATUS FOR FORMING HOLLOW TUBULAR BODIES FROM THE SOLID BLOCK.

the metal is materially increased; the walls of the flask show an equal solidity and a great tenacity in all parts, so that it can stand a pressure above 500 atmospheres. At a still higher pressure the flask does not break up into fragments, but only splits open at one place. The metal employed must possess a tensile strength 32 to 100 kg. per sq. millimeter, and an elongation of 15 to 30 per cent. After the operation it is found that not only the tensile strength, but also the elongation, has materially increased.

Practical experience has clearly proved the superiority of the Ehrhardt weldless tubes over the best welded tubes for water-tube boilers with thin tubes. For this several reasons are given: First, the metal employed is carefully chosen from among the best products of the Martin furnace, for in order to be able to stand this pressure operation it must be exempt from all defects resulting from casting; furthermore, the cherry-red heat at which the work is performed makes annealing superfluous and thus avoids its detrimental consequences. As there is no weld seam, the inner surface of the object shows no unevenness. The expansions and contractions which occur in the fireboxes of boilers take place in a regular manner, while a weld-seam, though as perfect as possible, breaks the homogeneousness of the metal and constitutes the primary cause for dislocations under the influence of varying temperatures. To this cause of inferiority must be added the difficulty experienced in obtaining an irreproachable seam. Lastly, the quality of the material employed for the seamless tubes allows of their being thickened up by upsetting, enlarged by bell-mouthing, or fitted with collars, etc., under the press, which

work cannot be executed with the same degree of perfection on welded tubes. Furthermore, there is no great difference to-day between the prices of production of the two kinds of tubes. The manufacture of welded tubes can only be termed economical in cases where the quality of the metal is of secondary importance owing to the low pressures it has to withstand, as, for instance, in gas and water pipes. The exigencies created by the progress of modern industry are, moreover, only to be satisfied by weldless tubes. Besides, the employment of first-class metal leads to a diminution of the thickness of the walls, and consequently also to economy. These weldless tubes are especially suitable for marine and locomotive boilers; the German Admiralty Office is using them exclusively. The manufacturing of shells has been improved; projectiles of extraordinary tenacity and solidity are thus produced, for which the hardest steel, with a tensile strength of 100 kg. per square millimeter and more, is employed.

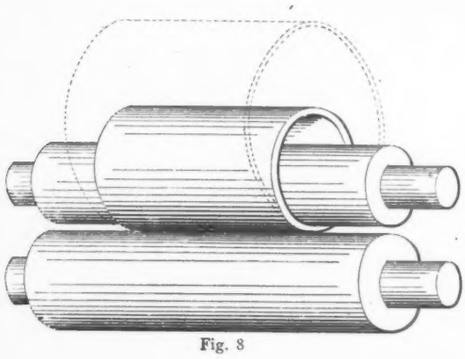


Fig. 8

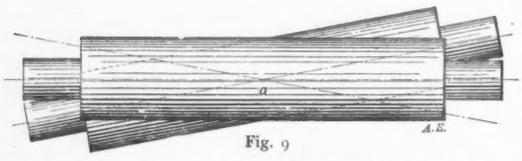


Fig. 9

ARRANGEMENT OF SWIVELING ROLLS FOR ROLLING OUT HEAVY TUBES INTO BOILER BARRELS.

Gun tubes, made from special alloys of steel, are first forged under a forging press and then punched by the Ehrhardt process, thus obtaining a high degree of resistance to pressure in the bore. By building up a gun from a tube and a jacket, both parts being manufactured by the Ehrhardt process and united by shrinkage, its strength is augmented still more. In consequence of the compression undergone by the inner layers of the tube while the bore is being pressed, the surface of the latter becomes very hard and compact, thus obviating to a great extent the erosion which the high temperatures accompanying the combustion of modern powders are liable to produce. In short, the products obtained by the Ehrhardt process are generally recognized to be of most excellent quality.

After having explained fully the Ehrhardt process in making seamless tube from a full square block, I will now explain this process as applied to the rolling out of a heavy tube, made in this manner, into a boiler-barrel.

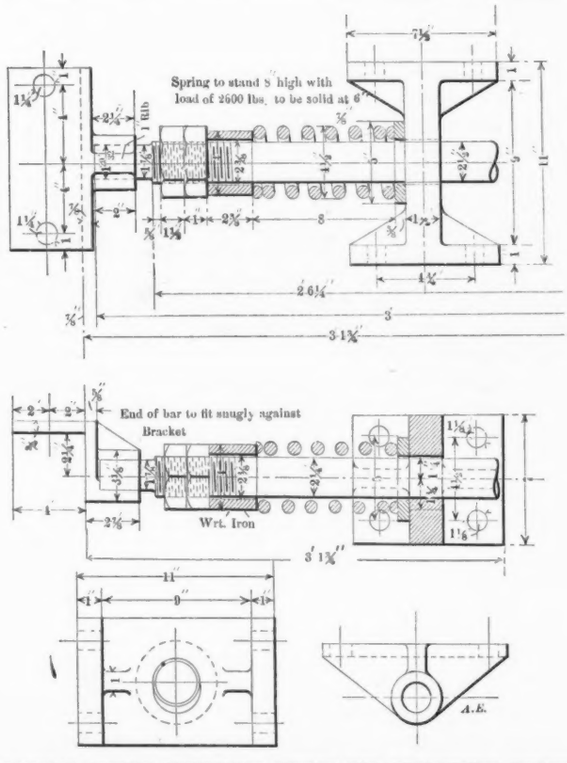
Mr. Ehrhardt uses a rolling mill with two rollers, of which the top roller takes the hollow block and the bottom one swivels in rolling. The hollow block is made of such a diameter that it goes easily over the top roller; the bottom of the blank is cut off so that a cylinder of the finished length remains. The rolling-out to the proper thickness and diameter is done on the rolling mill, which has a very powerful engine. The bottom roller is arranged to swivel right and left (Fig. 9) around the center-point a, and is pressed upward by hydraulic pressure, so that the same pressure is always acting. For facilitating the rolling out and reducing the pressure upon the rollers, the bottom roller oscillates during its work as shown in Fig. 9. In the inclined position the pressure is exerted only in the middle at a, and spreads gradually from the middle position until it covers the whole length of the rollers; as rollers always bend somewhat, this oscillating movement ensures uniform thickness of the cylinder. It is not thicker in the middle, as is usual with rolled plates. For guiding the rolled cylinder side rollers are used, which give a steady run to the cylinder. These side rollers are arranged so that they are fixed by a lever corresponding to the diameter of the boiler-barrel to be produced.

A boiler-barrel made in this way possesses in all its parts an equal resistance, and is far superior to a welded or riveted barrel. The press and rolling mill of Mr. Ehrhardt at Düsseldorf-Reisholz produces boiler-barrels for locomotives and marine from 1 to 5 meters (3.28 to 16.4 ft.) diameter, cylinders for hydraulic presses and accumulators, and all other kinds of hollow bodies of great resistance for great pressures. Locomotive and marine boilers made with seamless barrels, according to Ehrhardt's process, are lighter and of greater resistance, durability and tightness than those made according to the usual method, with welds and rivets.

SPRING CENTERING DEVICE FOR LOCOMOTIVE TRUCKS.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

In order to secure correct conditions of wear of driving wheel tires and to provide for the proper influence of the leading truck in guiding the engine, it is important to employ effective centering devices for the truck. On page 134 of the May, 1900, number of this journal was printed a discussion of



LATERAL SPRING CENTERING DEVICE FOR LOCOMOTIVE TRUCKS.

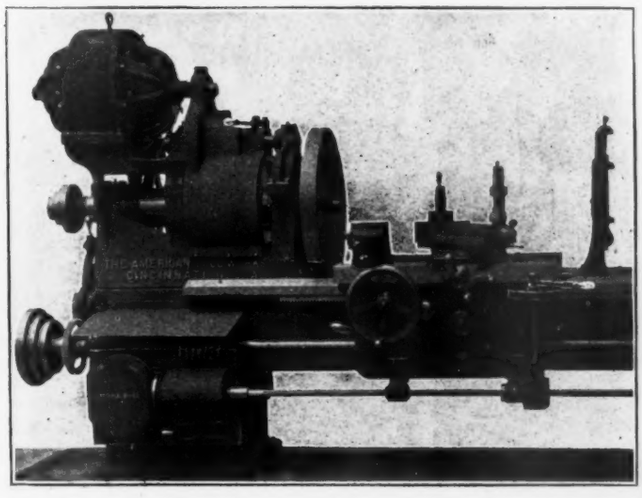
truck link hangers and their influence on the wear of tire flanges. There has been of late a marked tendency toward the use of 3-point truck hangers, employing the weight of the front end of the engine to center the truck. The accompanying engraving illustrates a lateral spring arrangement to serve this purpose. This is similar in principle to the devices which have been used for years in foreign practice and has been applied to the "Central Atlantic" or 4-4-2 type locomotives of the New York Central, which were illustrated on page 36 of the February, 1901, number of this journal. It is believed to be more satisfactory than the 3-point hanger and the construction is such as to permit of adjusting the resistance to side motion through the springs. The drawing is sufficiently clear to explain itself.

MOTOR DRIVEN MACHINE TOOLS.

REPRESENTATIVE EXAMPLES OF INDIVIDUALLY-DRIVEN LATHES.

Supplementary to our article in the previous issue (pages 137-9) descriptive of typical methods of applying electric motors to engine lathes for individual driving, we present herewith further examples of motor applications to lathes. All of the drives shown are those using direct-current motors, the majority being of the variable speed type; fewer examples of the induction (alternating current) motor are to be found as applied to machine tool driving, although the induction motor is meeting with marked success for this work and is fast coming into favor.

The writer is pleased to state that the machine tool builders are taking an exceptional interest in the subject of motor driving, and are for the most part conducting extensive experiments along this line. Important improvements in the method of mounting the motor, as well as in the arrangement of the drive, are to be found upon the advocated method of motor driving for every machine tool of prominence. The variable speed motor is held highly in favor by a great many, but the consensus of opinion seems to be tending toward the use of two or more runs of gearing in the drive to obtain a portion of the speed changes if a variable speed motor is used, or for all of the variations when using a constant-speed motor.

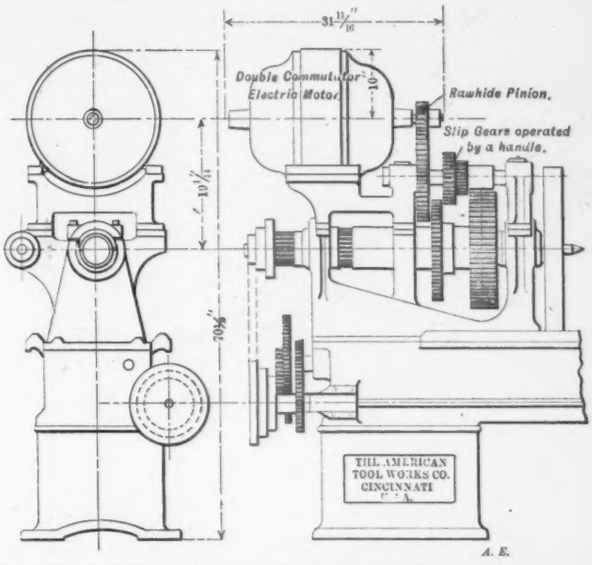


GEARED DRIVE FOR A 24-INCH LATHE.—AMERICAN TOOL WORKS CO. DOUBLE COMMUTATOR VARIABLE-SPEED MOTOR MADE BY THE COMMERCIAL ELECTRIC COMPANY.

The above illustration and drawing represent the interesting type of drive recently applied to their lathes by the American Tool Works Company, Cincinnati, O. The lathe here shown is their standard 24-in. lathe, which is well known for its many commendable features.

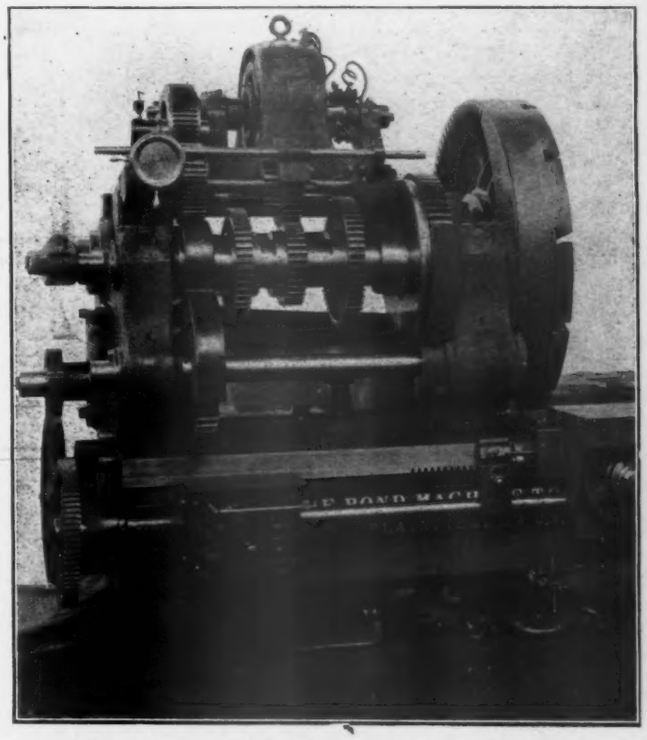
It is driven by a 3 h. p. motor of the double commutator type, made by the Commercial Electric Company, Indianapolis, Ind. The motor is mounted on a saddle on the headstock, with communication direct to the spindle by a rawhide pinion and intermediate slip gear. The controlling apparatus for starting, stopping and reversing is simply and conveniently arranged at the right end of the carriage, in the handle shown which operates through a splined controller rod beneath the bed. There are four fundamental speeds obtainable from the motor itself, through the speed controller directly under the head, which operates upon the two wire system in conjunction with the double commutator feature of the motor. This, with the four speed changes in the spindle gearing, gives a total of sixteen distinct and positive spindle speeds available.

The drawing presents the details of the headstock gearing arrangement. The motor drives through the pinion to an intermediate shaft which carries two slip gears, splined so as to permit of being thrown over into mesh with either run of gearing. The movement of these slip gears is controlled by the handle shown above the gear case in the view. These two runs of gears, in addition to the regular back gear attachment, provides the four changes of speed available from the headstock gearing.


Double Commutator Electric Motor.
Rawhide Pinion.
Slip Gears operated by a handle.
THE AMERICAN TOOL WORKS CO. CINCINNATI
A. E.

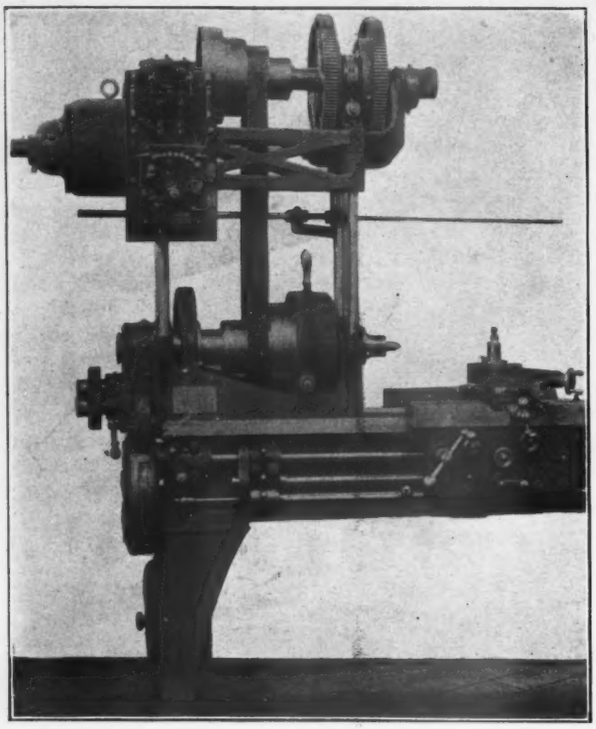
DRAWING SHOWING ARRANGEMENT OF CHANGE GEARS FOR THE DRIVE UPON THE AMERICAN TOOL WORKS LATHE.

Below is illustrated an interesting motor drive which has been applied to a 54-in. engine lathe made by the Pond Machine Tool Company. The motor is a 7½ h. p. Westinghouse motor, having a speed range from 650 to 930 rev. per min. by field control. It is mounted upon a saddle spanning the headstock frame, from which position it drives an intermediate shaft in



GEARED DRIVE UPON A 54-INCH LATHE.—POND MACHINE TOOL CO. VARIABLE-SPEED MOTOR (FIELD CONTROL).—WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY.

front. Upon this intermediate shaft is arranged a slip-gear combination consisting of three pinions in one piece, splined so as to slide along the shaft. Their position is controlled by the hand wheel shown at the left—by it they may be thrown over so as to mesh with any one of the three larger gears upon the driving shaft below. The three gear speeds thus obtain-



CONSTANT-SPEED BELTED DRIVE UPON AN "IDEAL" LATHE.—SPRINGFIELD MACHINE TOOL COMPANY.

able are supplemented by the usual back-gear attachment, making thus six spindle speeds available for every motor speed.

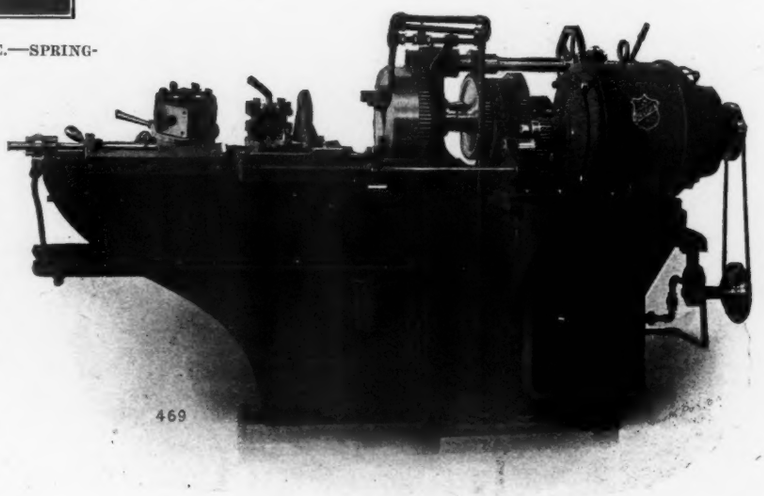
The lathe illustrated in the engraving above is the motor-drive adaptation of the Ideal lathe, a number of which have been furnished to the United States Navy Department by the Springfield Machine Tool Company, Springfield, Ohio. This is the belted or flexible connection type of drive for use with constant-speed motors, which this company has advocated, and it has proven very satisfactory. The motor is not reversible, reversals being accomplished, as well as starting and stopping, by the clutches on the countershaft upon the standard. This arrangement, of course, necessitates a tight belt on account of the close centers of pulleys. The motor shown upon this lathe is a Storey direct-current constant-speed motor.

This company has recently developed an improved arrangement of geared drive, which marks an important advance in motor driving applications. They are making unusual progress in this important branch of work.

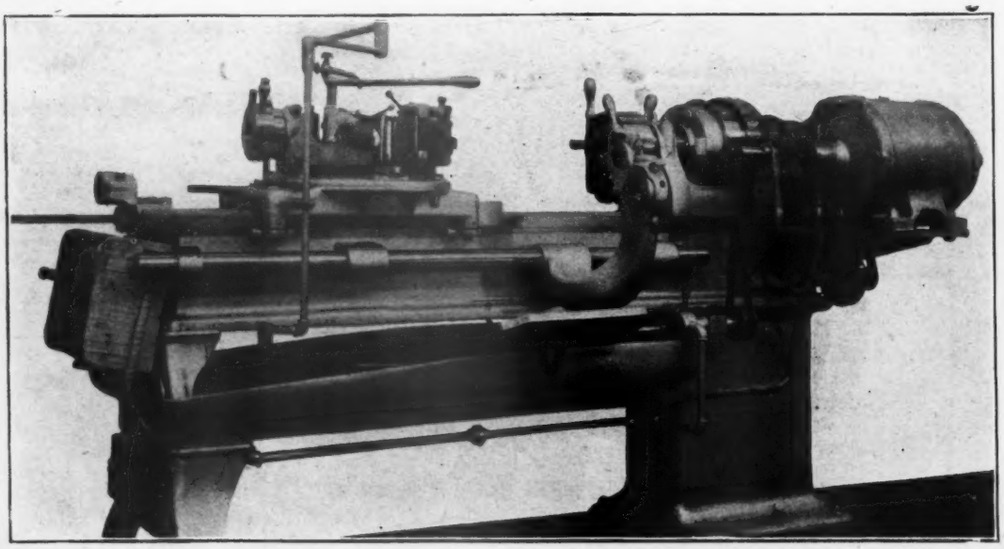
The lower engraving illustrates a motor drive application to a Jones & Lamson flat turret lathe. The motor, which is a type N direct-current motor made by the Bullock Electric Manufacturing Company, Cincinnati, O., is conveniently located upon a cast-iron bracket at the rear of the headstock. The motor drives direct through an intermediate pinion to the large spindle gear. A valuable feature of this application is the fact that all the gears are encased in a sheet metal casing, keeping out dirt and preventing injury to the gears, or to workmen.

The motor is operated upon the multiple-voltage system for variable speeds, the controller for which is shown located at the end of the bed at the left; the handle projects out on the front side of the lathe. This controller gives 26 speeds in forward motion and six in reversal.

Another application of the multiple-voltage motor drive is presented in the engraving below. This illustrates a 13-in. Gisholt turret lathe gear driven direct from a type N variable-speed motor made by the Bullock Electric Manufacturing Company. The drive is in this case also from the motor pinion through an intermediate gear direct to the spindle. The 26 speeds furnished by the controller are here assisted by the use of the usual back gear upon the lathe.



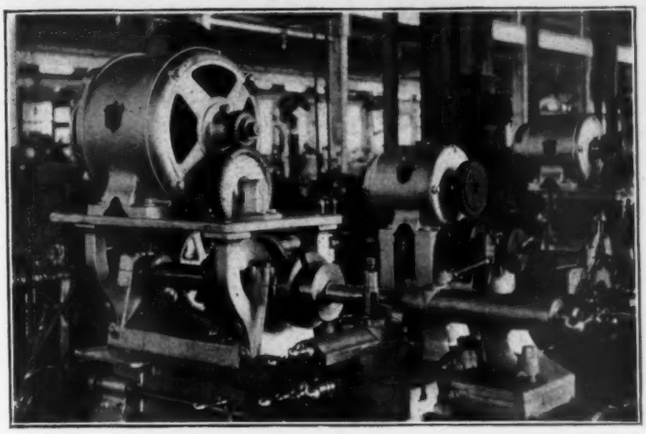
GEARED DRIVE UPON A TURRET LATHE.—GISHOLT MACHINE COMPANY.
MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING COMPANY.



DIRECT GEARED DRIVE UPON A JONES & LAMSON FLAT TURRET LATHE.
MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRICAL MANUFACTURING COMPANY.

The motor is supported by a convenient cast-iron bracket at the rear of the head.

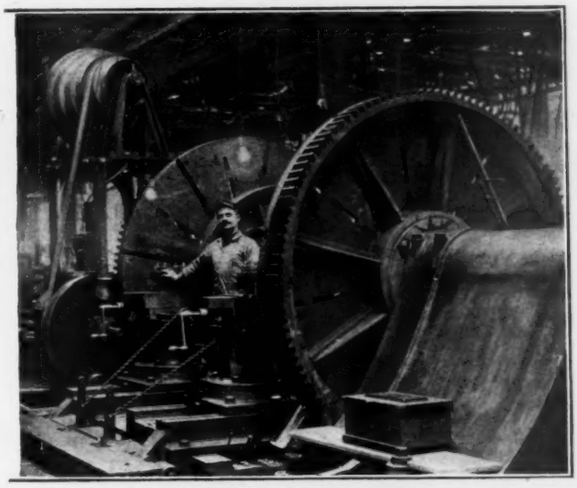
Some interesting lathe drives are shown in the upper engraving on page 195, which represents a view in the tool room at the Bullock Electric Manufacturing Company's works. The drives shown are cases where multiple-voltage motors have been mounted upon standards above the lathe headstocks and drive direct to the spindles by gearing. In all these cases the motor's variable speeds are supplemented by the lathe back-



GEARED DRIVES UPON TOOL ROOM LATHES AT WORKS OF BULLOCK ELECTRIC MANUFACTURING COMPANY.

gears. A very noticeable feature of this tool room is the absence of belts and also the simplicity of the headstock arrangement effected by the use of the variable-speed motor.

The following engravings present views of a "home-made" application of motor driving to a large Bement-Miles wheel lathe in a prominent railroad repair shop. The motor used is a constant-speed General Electric motor, and with the driving cone pulley, it is mounted upon a platform of boiler plate, supported by cast-iron pillars bolted to the headstock. This is a convenient method of adapting an old tool to motor driving—the principal criticism lu this case is the lack of a means of easily raising the drive cone to tighten the belt.



CONSTANT-SPEED MOTOR DRIVE UPON A LARGE BEMENT-MILES WHEEL LATHE.—AN ADAPTATION TO AN OLD TOOL.

LOCOMOTIVE TESTS ON THE PRUSSIAN STATE RAILWAYS.

Superheater and Compound Locomotives.

(TRANSLATED EXTRACTS FROM REPORT BY HERRN PROF. VON BORRIES.)*

In the summer of 1902 tests were made on the Prussian State Railways with four-cylinder balanced compounds of the Von Borries type and the latest type of superheated steam single-expansion locomotives of the Schmidt-Garbe system. The results of these tests, which were made on the Hanover-Stendal division, are given below. The locomotives tested were two four-cylinder compound engines, Nos. 17 and 18, two superheater locomotives, Nos. 439 and 440, and a two-cylinder compound locomotive with starting valve, No. 42. These engines are all of the four-coupled (4—4—0) type, their main dimensions being:

Type.	Numbers.	Weight in Working Order. Pounds.	Grate Area, Sq. Ft.	Heating Surface, Sq. Ft.	Boiler Pressure, Lbs. Sq. Ins.
Four-cylinder compound.	17, 18	116,500	24.7	1,278	200
Super-heater	439, 440	120,350	24.7	1,134	170
Two-cylinder compound.	42	104,900	24.7	1,345	170

In calculating the average figures which are tabulated below, all those which were not properly comparable by reason of unfavorable weather conditions have been discarded, the number of trips considered being as shown in the first line of the table. In calculating the hourly fuel and water consumption per square foot of grate area and heating surface (lines 22 and 23), a deduction of five minutes has been made from the total running time (line 2) to give actual time at speed, exclusive of slow-down on passing through Lehrte station and at the ends of the run. This deduction was, however, not made in calculating the horse-power developed per pound of coal (lines 18 and 19), in order to make allowance for the work done in accelerating the train, which is not otherwise accounted for.

The four-cylinder compound engines gave almost identical results. The fuel and water consumption (lines 22 and 23) of respectively 90.1 and 13.2 pounds per foot are below the allowable maximum values of 97 and 14.5 pounds per square foot per hour, showing that the engines were capable of developing greater power, which was actually done on some trips. The superheater locomotives show an hourly evaporation of 13.8 pounds per square foot of grate, which is slightly below, while the fuel consumption of 98.6 pounds per square foot of heating surface is somewhat above, what may be considered the allowable maximum, so that the engines were on the average fully loaded.

A comparison of the smoke-box draught (line 5) shows that the same rate of combustion was attained with a much lower vacuum for the superheater engines. The same thing was shown by a measurement of the temperature of combustion. In making this measurement the vacuum in the rear upper corner of the fire-box was measured and found to average for the four-cylinder compound about 54 per cent., and for the superheater about 45 per cent. of the vacuum in the smoke-box, the difference being doubtless due to the greater area of the flues in the superheater locomotive. The total horse-power (line 13) is about 5 per cent. higher for the superheater than for the four-cylinder compound, chiefly on account of the 9 per cent. greater evaporation (line 22). The effective horse-power developed per pound of coal per hour is, on the other hand, about 7 per cent. better for the four-cylinder compound. In comparison with the earlier superheater engines tested in 1901, the power of the new engines (lines 13, 14, 18, 19 and 20) is higher by about 12 per cent. on the average. This is in accordance with the expectation expressed (by Herrn von Borries) in reporting the tests made on the previous engines.

In regular express service on the Stendal division between June 1 and August 15 the coal consumption per train-mile

*Zeitschrift des Vereins Deutscher Ingenieure of Nov. 22, 1902.

amounted on the average to the figures given below, and the individual figures did not show any great variation:

3 Four-cylinder compounds..... 39.41 pounds
2 Superheaters ..... 40.15 pounds
1 Two-cylinder compound..... 39.80 pounds

On the Halle division the following figures were obtained:

Type of Engine.	Average Consumption per Engine Mile. Coal.	Water.
Four-cylinder compound	38.89 lbs.	270.7 lbs.
Superheater	37.89 lbs.	226.9 lbs.

The power of both types was practically the same.

Taking all of the tests of express engines together, the results lead to the following conclusions: The four-cylinder compounds run very quietly and evenly, with absolutely no pound in the machinery, and this easy riding has a very favorable effect on the comfort of the crews, who for this reason prefer these engines to any others. The cost of maintenance of track and engines should also be favorably influenced. The power developed by these four-cylinder compounds was cut down considerably by the dampness of the steam, and it would be advantageous, in order to secure greater economy with future engines, to arrange to use steam superheated to about 482 deg. Fahr. This would give a desirable increase of power and a reduction of the fuel and water consumption.

The superheater engines showed, as was noticed above, an increase of power (lines 13 and 14) in comparison with the engines tested in 1901. This increase amounted to about 15 per cent. and is mainly due to the increase of the cylinder diameter from 18.11 ins. to 20.47 ins., which enabled the test trips to be made with an average cut-off of 15 per cent. of the stroke instead of 26 per cent., as previously. As this cut-off may be regarded as the most economical, the present cylinders appear to give the best possible steam distribution, so that no further increase of power is to be looked for with these engines while single-expansion cylinders are used. The power developed per pound of fuel (line 18) is somewhat less with the superheaters than with the four-cylinder compounds, and consequently the power developed per pound of total engine weight cannot be greater for a superheater locomotive than for a four-cylinder compound, and therefore in my opinion it will not be practicable to build superheater locomotives of the 4—4—0 type to give the same power as the 4—4—2 and 4—6—0 type four-cylinder compounds, which with from 2,150 to 3,200 sq. ft. of heating surface develop from 1,300 to 1,600 h.p. The increase in cylinder diameter increased the piston stroke, which consequently gave rise to a considerable shaking of the engine, which was very unpleasant for the crew and bad for the maintenance of the machine.

FREIGHT ENGINES.

The eight-wheeled eight-coupled (0—8—0 type) superheater freight engines were thoroughly tested on the Saarbrucken division. Four of these engines and four compound locomotives of the same type were used for hauling heavy ore and coke trains on the Mosel Railroad. The maximum loads for the grades of 1 per cent. were calculated at 100 loaded car axles for the superheater, weighing 121,700 lbs., and 90 axles for the compound, weighing 116,800 lbs. In actual service the trains averaged 107 axles for the superheaters and 100 for the compounds. The coal and water consumption per 1,000 loaded axle-miles averaged:

Type of Engine.	Coal.	Water.
Superheater	605 lbs.	4,092 lbs.
Compound	565 lbs.	4,465 lbs.

These show that the superheaters worked with 8.7 per cent. less water but used 6.3 per cent. more coal. On a neighboring road two superheaters consumed 663 lbs. of coal per 1,000 axle-miles, as did the compounds, so that no saving was shown. If the compound locomotives had been of the same weight and had had piston valves like the superheaters for the high-pressure cylinders, the power and coal consumption for full loaded trains would probably have been practically the same.

The results as they stand are somewhat surprising, as it was to be expected that freight service was just where the superheaters would make a particularly good showing, owing to their better adaptation to the varying tractive power and to their better draught with four exhausts in each revolution. The small amount of economy shown in the water consumption leads one to suspect steam losses which might be due to leakage past the piston valves.

CONCLUSIONS.

From the combined results of all these tests I consider it unwise to abandon the use of compound cylinders with the introduction of superheated steam. On the contrary, I believe that the four-cylinder compound locomotive will be found in every way the most appropriate for the requirements of the future. The two-cylinder single-expansion engine has its best opportunity in freight service, where, on account of the low speed, the high piston pressure is less injurious; and yet even here a test with superheated steam and compound cylinders might be advisable.

TABLE OF RESULTS OF TESTS.

Number.	Item.	Unit.	Four-Cylinder Compound.	Superheat.	Two-Cylinder Compound.
1.	Number of trips		20	22	12
2.	Total running time, Hanover to Stendal, or back	min.	112.3	108.5	114.7
3.	Actual running time in Gross Mohringen block (77.7 miles)	min.	84.7	82.4	85.8
4.	Average speed in the block (V)	miles pr. hr.	54.8	56.4	54.0
5.	Average vacuum in smokebox	inches of water	3.56	3.86	4.24
6.	Average cut-off in per cent. of stroke	per cent.	34	15	45
7.	Average temperature of steam	degrees F.	....	527	....
8.	Average weight of locomotive and tender (L)	Tons (2000 lbs.)	95.75	98.10	83.45
9.	Average weight of train (W)	Tons	315.0	302.1	283.8
10.	Average tractive power for engine and tender $T_1 = L\left(7.6 + 4.6\,V\,\frac{V+20}{1{,}000}\right)$	lbs.	2515	2685	2165
11.	Average tractive power for train $\left(T_2 = W\,3.2 + 1.55\,V\,\frac{V+31}{1{,}000}\right)$	lbs.	3310	3275	2920
12.	Average total tractive power $(T_1 + T_2)$	lbs.	5825	5960	5085
13.	Average horse-power $\left(\frac{T_1+T_2}{375}V\right)$	H. P.	851	897	732
14.	Average useful horse-power $\left(\frac{T_2}{375}V\right)$	H. P.	484	492	420
15.	Water used in single trip	lbs.	25600	22900	25100
16.	Coal used on round trip	lbs.	6660	7030	6470
17.	Water evaporated per pound of coal	lbs.	7.68	6.54	7.77
18.	Horse-power developed per pound of coal per hour $\left(2\frac{\text{No. 2}}{60}\cdot\frac{\text{No. 13}}{\text{No. 16}}\right)$	H. P.	0.48	0.46	0.43
19.	Useful horse-power developed per pound of coal per hour $\left(2\frac{\text{No. 2}}{60}\cdot\frac{\text{No. 14}}{\text{No. 16}}\right)$	H. P.	0.27	0.25	0.24
20.	Useful horse-power developed per ton of locomotive, exclusive of tender $\left(\frac{\text{No. 14}}{\text{weight}}\right)$	H. P.	8.30	8.16	8.00
21.	Actual effective running time (No. 1, less 5 minutes)	min.	107.3	103.5	109.7
22.	Water evaporated per square foot of heating surface per hour $\left(\frac{\text{No. 15}}{\text{heating surface}}\cdot\frac{60}{\text{No. 21}}\right)$	lbs.	13.2	13.8	12.1
23.	Coal burned per square foot of grate per hour $\left(\frac{\text{No. 16}}{2\times\text{grate area}}\cdot\frac{60}{\text{No. 21}}\right)$	lbs.	90.1	98.6	86.6

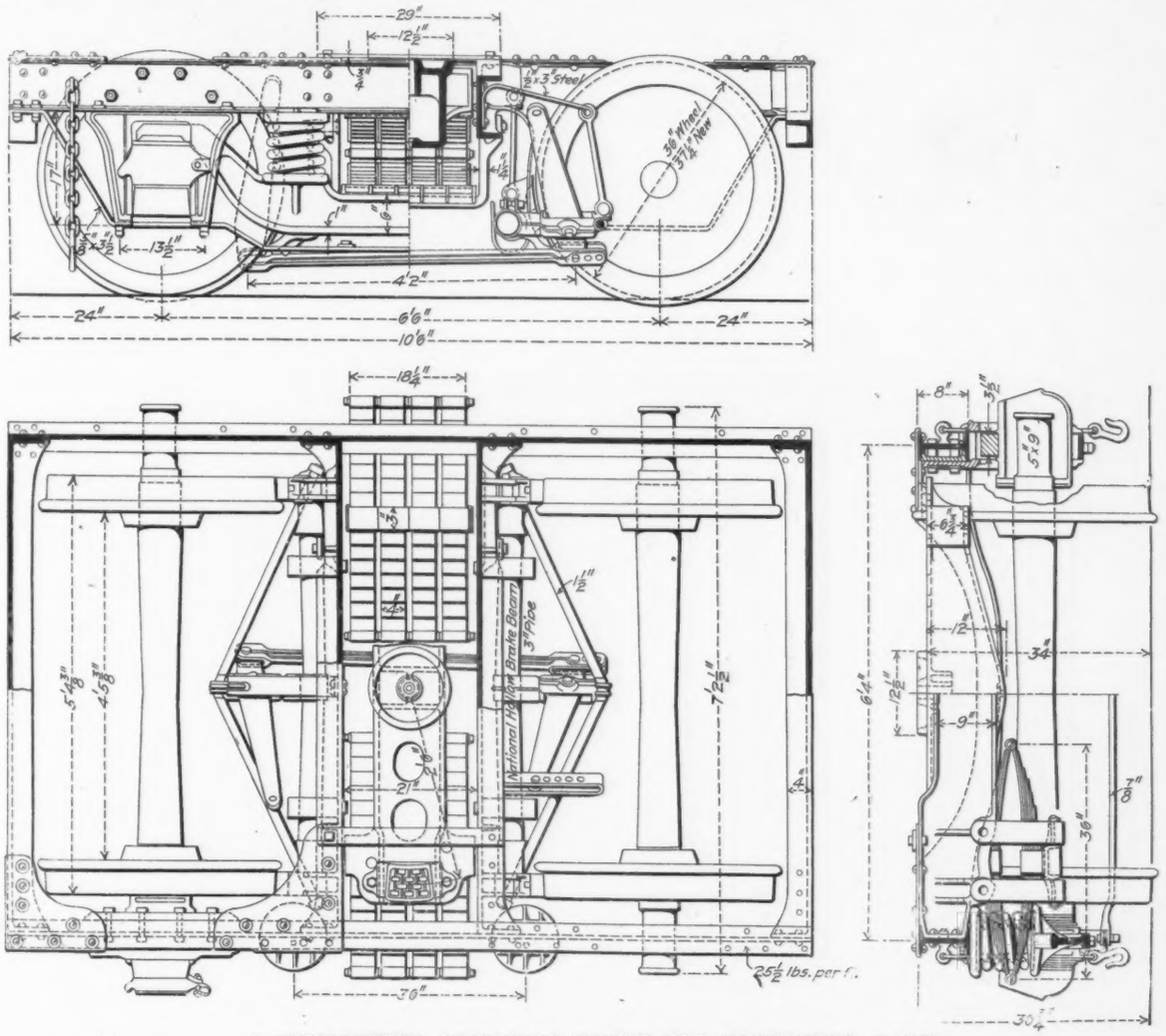
The sudden death of W. W. Card in Pittsburg, April 4, brings a shock to many who have known him for years, and it has brought tributes from all directions to his memory as one of the prime movers in the development of the air-brake. He was in his 72d year, having retired from the Westinghouse Air Brake Company only last year. He entered its service in 1872, became secretary in 1879, and was closely associated with Mr. George Westinghouse in bringing the air brake to its success.

METALLIC TRUCK FOR PASSENGER CARS.

FOUR-WHEEL, WITH 5 BY 9 INCH JOURNALS.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

A number of steel passenger car trucks have been brought out within a few years in an effort to reduce weight and complication. The Lake Shore & Michigan Southern metallic truck (AMERICAN ENGINEER, January, 1901, page 12) has given good results under postal cars, where it has replaced six-wheel trucks, and the riding qualities do not appear to be inferior. If four-wheel trucks can be made to ride well, there is no doubt of their place in passenger equipment practice in the future.



A FOUR-WHEEL METALLIC TRUCK FOR PASSENGER CARS.
ATCHISON, TOPEKA & SANTA FE RAILWAY.

This truck employs the M. C. B. 5 by 9 in. axles. Its side pieces are 8 in. 25½-lb. I-beams with cast steel truck end sills and cast iron transoms. The truck bolsters and equalizers are also of cast steel. The method of spring suspension is clearly indicated in the drawing. Cast steel gusset connections are used to stiffen the attachments of the end sills and transoms. Other details of construction are shown in the engraving. The weight of the truck, complete with brake rigging, is 12,600 lbs. It is equipped with roller side bearings.

These trucks have already been used under ten baggage and five combination baggage cars built for this road by the Pullman Company last year, and they will also be used under ten similar cars now being built. These interesting drawings have been received from Mr. G. R. Henderson, superintendent of motive power of this road.

LOCOMOTIVE TESTS—ATCHISON, TOPEKA & SANTA FE RAILWAY.

NARROW AND WIDE FIREBOXES AND COMPOUNDING.

Now that the wide firebox is a feature of so large a proportion of the locomotives being built, and the merits of compounding still being under such serious discussion, the results of some tests taken under the most favorable conditions for determining the relative advantages of these two features of locomotive design seem worthy of consideration.

The tests under discussion were made on two consolidation engines having identically the same tractive force, viz., 40,000 lbs., one engine having 22 x 28-in. simple cylinders, with piston valves and a narrow firebox, the other engine having tandem-compound cylinders, 16 and 18 x 32 ins. and wide firebox. (See AMERICAN ENGINEER, June, 1902, page 179). Both engines carried 210 lbs. of steam and had 57-in. drivers. Below is a comparative table showing the leading dimensions of the two engines:

COMPARISON OF LOCOMOTIVES.

	Simple.	Tand.-Comp.
Cylinders	22 x 28 ins.	16 & 28 x 32 ins.
Steam pressure	210 lbs.	210 lbs.
Diameter drivers (outside)	57 ins.	57 ins.
Firebox	41¼ x 121 ins.	71¼ x 97 ins.
Tubes—		
Number	411	355
Diameter	2 ins.	2 ins.
Length	13 ft. 6 ins.	15 ft. 0 in.
Wheel Base—		
Rigid	15 ft. 4 ins.	15 ft. 4 ins.
Engine	23 ft. 8 ins.	24 ft. 1 in.
Total	53 ft. 5 ins.	53 ft. 10 ins.
Weights—		
On drivers	180,000 lbs.	174,000 lbs.
Engine	197,000 lbs.	199,200 lbs.
Total, engine and tender	309,900 lbs.	316,700 lbs.

The tests were made on a heavy grade 65.4 miles long, the first 49 miles of 53 ft. to the mile and the last 16.4 miles 74 ft. to the mile. It was a dead pull the whole distance, there being no "let-ups." The conditions were fair in both cases, the engines steaming well, their machinery being in good shape and there being practically no leaking. The object of the tests was to determine the coal consumed per 100-ton miles, and the only data taken beyond the general conditions were the coal burned and the tonnage handled.

The actual coal burned per trip on the simple engine was about 25 per cent. greater than that on the compound, but the difference in the coal burned per 100-ton miles on the two engines, which is the true measure of the work performed, was greater than this, due to the compound engine handling from 150 to 250 more tons per train than the simple engine. The rating for the two engines on the grades mentioned is as follows:

	Simple.	Tand. Comp.
On 53-ft. grade	1,050 tons	1,250 tons
On 74-ft grade	850 tons	1,000 tons

These engines made with this tonnage an average speed while running of nearly 13½ miles per hour.

Below is the coal consumption, being an average of the tests made:

	Simple.	Tand. Comp.
Coal burned per 100-ton miles	30.9 lbs.	21.0 lbs.
Difference in favor of tandem-compound engine, using simple engine as a basis	32.04 per cent.	

It would be interesting to know how much of this saving was due to the wide firebox, increasing the efficiency of the boiler, and how much to the compounding. But as such information would be very expensive to secure, involving as it does long series of tests with costly changes in the engine, it would probably be impossible to get a managing official to sanction the expenditure.

We are indebted to Mr. G. R. Henderson, superintendent of motive power, and Mr. R. S. Wickersham, assistant engineer of tests, for this interesting information.

LIQUID FUEL BURNERS.

"There are several good burners in the market and many more which are simply mechanical monstrosities. Some burner enthusiasts are often heard to claim that they could save from 25 to 50 per cent. of the oil used by any other burner. To show the unreasonableness of such claims it is enough to direct attention to the fact that with a properly set stationary boiler 15 to 15½ lbs. of water may be evaporated from and at 212 deg. per pound of oil, containing, say, 14,000 B. T. U. per pound. With the losses due to stack temperature and radiation, 80 per cent. of the theoretical evaporative duty of the fuel is about as good as we can get. Taking the theoretical evaporation of our oil at 19.6 lbs. of water per pound of oil, we have 15.6 lbs. of water evaporated, which is very close to the result stated, the loss being due entirely to stack temperature and to furnace setting. I have seen very few burners which would not atomize well enough to give 13 lbs. evaporation, and with the majority 14 to 15 lbs. is the rule. Now, if the inventor who is going to save 50 per cent. can evaporate even 13 lbs. of water with one-half pound of oil, he has certainly equalled the solution of the problem of perpetual motion."

This paragraph is quoted from a paper entitled "Liquid Fuel" read before the American Society of Naval Engineers by Mr. W. D. Hoffman, associate member of the society. It is the best discussion of the subject we have seen, because it presents information from a wide experience and deals with principles. One of the chief of these is the necessity for such furnace construction as will permit of sufficient length of flame to insure combustion of the oil. The main point in handling oil fuel is the construction of the furnace. Mr. Hoffman gives very valuable information concerning liquid fuel as applied to locomotives, Mr. Hoffman in this paper has established his position as an authority on liquid fuel. It is a matter of regret that space permits of only a brief reference to it here.

MICA METALLIC PACKING.

As steam pressures and the exactions of service of steam engines of all types increase, the matter of good valve-stem and piston-rod packing becomes correspondingly more important. This is particularly true of locomotive service, where mileage in times of stress of business depends largely upon the efficiencies of relatively small details of design and construction.

Mica metallic packing has been developed to meet the requirements of engines, pumps, steam hammers, air compressors; in fact, for every form of rod packing, and especially upon locomotives. It is reported to be giving good results in all of these services. It is made in the form of rings, and the following advantages are urged in its favor:

It is intended to work equally well with or without lubrication, and this is specially important for packing in inaccessible places. This is a pliable material and fits the rod by virtue of the compression of the gland, and is not dependent upon the actual fitting of the packing because of its form. It is said that the packing need not be removed from the rod when worn so that it blows. The remedy is to add another ring. This packing is stated to be self-adjusting to fit worn or fluted rods, so that it will by the pressure of the gland, be compressed to fit all openings. A packing which becomes hard in service may require chipping for removal. It is claimed that this packing always remains soft, so that it may, if necessary, be blown out. Packing which will fulfill these requirements has strong claims for the attention of railroad officers. The manufacturers are the American Metallic Packing Company, Williamson building, Cleveland, Ohio.

BLUE LEAD AS A PIGMENT FOR PAINTS.

An argument in favor of graphite as a pigment for paint has been received from the manufacturers of a successful paint. It is reproduced as follows:

When pure linseed oil is applied to a wood or metal surface and is allowed to remain a sufficient time, it leaves a tough film over the surface. This film is full of minute pores. That this coating may exclude moisture and corrosive gases from the covered surface these minute pores must be closed. Pigments are put into paint for this purpose. The substance that can most completely close the pores of this oil coating, that is itself the most indestructible and that does not have an injurious effect upon the surface to be protected, makes the best paint, provided its specific gravity be right.

Red lead is very heavy. For this reason it makes a good coat for the top of horizontal surfaces and is really unsuited for all others. The weight of the particles makes the pigment settle through the film of oil and causes the paint to stick closely to top surfaces. Red lead will streak on vertical surfaces and is unsuited for use on under sides. Another very grave difficulty with this pigment is that it is impossible to keep it from settling and hardening in the package after it is mixed without the introduction of material injurious to the quality of the paint produced.

Graphite is a very light pigment and is most admirable for under sides and vertical surfaces, where it makes a closely adherent coating. On upper surfaces it is not equal to red lead, as the pigment rises to the top of the oil film in such cases. Iron oxides, or metallic paints, as they are popularly called, are not to be relied upon unless the chemical composition of the pigment is accurately known. In many cases so-called iron oxide paints accelerate rather than retard the corrosion of steel structures.

The pigment which is believed by these manufacturers to most nearly fill the requirements of a perfect paint is made by a special sublimation process from native high-grade

galena. In color it is a dark steel blue. It is of such a fluffy fineness and it has such an avidity for oil that the paint when dry makes a hard, enamel-like coating. That the pores of the oil film are closed absolutely by this pigment is evident from the long and trying tests this paint has endured without injury. The pigment itself is chemically durable and is proof against any acid or gas encountered in practice. It is neutral toward metal surfaces and is entirely non-corrosive. The specific gravity of this pigment is such that it makes a smooth, uniform mixture and never settles sufficiently to become hard in the package. Its specific gravity lies between that of red lead and graphite and enables it to be used with most satisfying results on any surface, horizontal or other. Its fineness makes it an exceptionally smooth and pleasing paint to apply.

The American Graphite Company, of Cleveland, Ohio, who manufacture this paint under the name of "T. A. G." Blue Lead, say they believe, from the tests which it has withstood, that there can be no doubt that it is a distinct step in advance and the most nearly perfect protection yet attained.

We are interested to learn that the Continental Iron Works, Brooklyn, N. Y., have recently installed a system of alternating current (two-phase) power distribution to replace their former direct current system. Some time ago a small trial system was installed for operating a portion of their machinery by induction motors, as a result of which the new system was installed, including a 180-kw. two-phase alternator, a five-panel switchboard, eleven induction motors of from 5 to 20 h.p. each, with the accompanying auto-starter, all of Westinghouse make. The company some time ago installed an alternator of 120 kw. capacity, and they also have quite a number of induction motors in use driving corrugating and bending rolls for making Morrison fire boxes, also driving fans, shears, tools in the machine shop, etc. Some of the motors which have recently been purchased are to displace direct-current motors, and this after a thorough and careful investigation of the subject and several years' trial of the induction motors. We learn also that the Riter-Conley Manufacturing Company, of Pittsburgh, Pa., has adopted alternating-current motors exclusively for power distribution. They have installed three 200 kw. engine-type Westinghouse generators, direct-connected to Westinghouse gas engines using natural gas. Alternating current motors will be used for all purposes, including cranes, straightening rolls, etc.

BOOKS AND PAMPHLETS.

The World's Famous Railway Trains, British Expresses, Etc. Reprinted from the *Locomotive Magazine*, London. Special series, Nos. 1 to 6. 8 x 11 portfolio, handsomely illustrated. Artistically bound in blue and silver. Published by the Locomotive Publishing Company, Ltd., London. For sale by the Derry-Collard Co., 256 Broadway, New York. Price $1.50.

This volume is a reprint of a series of special illustrated issues of the *Locomotive Magazine* that have appeared at intervals during the last few years. The striking feature of these special editions is the profuse illustrations which present a comprehensive idea of foreign motive-power and rolling-stock practice which it would be difficult to otherwise obtain. The following are the subjects presented in the work: "British Expresses," "The World's Famous Railway Trains," "The British Express Locomotive," "Locomotives of 1900," "Locomotives at Work," "Cars of 1900" and "Locomotives of All Nations." Each subject is treated in a highly interesting manner. All the trains illustrated are from photographs taken when under full speed, while the comparative works upon locomotives and cars show principal dimensions. The typographical work is beautifully executed, the engravings are large and clear, and several colored supplements are included. To those interested in foreign locomotives or in typical railway views we heartily commend this interesting volume.

Continuous-Current Dynamos and Motors, and Their Control. By W. R. Kelsey, B. Sc., A. I. E. E. 440 pages, fully illustrated. The Technical Publishing Company, Ltd., 55 Chancery Lane, W. C., London, 1903. Price 5s.

The first portion of this volume is a reprint of a series of articles that appeared in the *Practical Engineer*, London, for which the author is in no way responsible. In this portion an excellent treatise on the basic principles of electricity is presented. The object of the work is to indicate the ways in which the principles are applied in the design and construction of dynamos and motors. Particular stress is laid upon the mechanical points involved in such work, for which this book is of unusual value. One of the principal features of this book is the very complete treatment of electric traction, with reference to the motors and their gears. Flux-speed-torque curves are presented which are of especial value, and, also, the subject of railway controllers is treated in a very comprehensive manner. This volume will be appreciated by all interested in electric railway practice.

Engineering Contracts and Specifications. By J. B. Johnson. Third edition revised. Fourth thousand. Engineering News Publishing Company, New York, 1902. Price, $3.00.

Typographically this edition, like the others, leaves something to be desired, but this does not very seriously affect the value of the substance. In this revised edition, Part I, "Synopsis of Law of Contracts," and Part II, "The General Treatment of Engineering Specifications and Accompanying Documents," 124 pages, appears to be unchanged. Part III, "Specific Description of Technical Clauses in Specifications," has undergone revision and certain parts have been rewritten, the changes being mainly in the new specifications for "First-Class Masonry," "Cast Iron Water Pipes," "Riveted Steel Water Pipes," "Wooden Stave Pipes," "Wrought Iron Chains," "Street Pavements and Materials" (mainly brick), and "Rules Governing Inspection and Measurements of Lumber in St. Louis." These, in part, are substituted for other subjects, so that little increase in amount results. Part IV, "Illustrated Examples of Complete Contracts and Specifications," show an increase of 130 pages from the first edition and is new in a very considerable degree—although it goes without saying that a number of the old specifications are still so good that nothing better in their line could well be substituted. Altogether the book is distinctively more valuable than the earlier editions. For the frontispiece there is, very appropriately, an excellent portrait of Professor Johnson, whose last work previous to his death by accident was the preparation of the manuscript for this revision.

Fan Motors.—A new catalogue has been received from the Westinghouse Electric and Manufacturing Company, describing and illustrating alternating and direct-current fan motors. It describes a number of types of these convenient machines and by means of excellent engravings impresses the reader with the desire to have one of these upon his desk. Several important improvements are incorporated in the designs presented this year, indicating the characteristic effort constantly made by the Westinghouse Company toward perfection of their apparatus.

Record of Recent Construction No. 41, issued by the Baldwin Locomotive Works, contains photographs of a number of notable trains hauled by Vauclain compound locomotives, constructed at these works. Among the number are the "Atlantic City Flyer" of the Philadelphia & Reading, the "Alton Limited," the "Overland Limited" of the Union Pacific, the "Overland Limited" of the Southern Pacific, the fast mail of the Burlington and a number of other fast and notable trains. It is typographically a very attractive issue of this series, and presents an interesting record of the Vauclain compound in fast passenger service.

"A Portfolio of Rare Views" is a work of art issued by the passenger department of the Boston & Maine Railroad, which forms one of the series of pamphlets of views of beautiful New England scenery on the line of this road. This portfolio contains thirty-three reproductions of photographs of scenery on the Fitchburg division, presenting a panorama of the delightful Hoosac country and Deerfield Valley. It abounds in waterfalls and mountain views of one of the most attractive regions in the world. The title of the pamphlet is "The Charles River to the Hudson." It will be mailed to any address upon receipt of 6 cents in stamps by Mr. D. J. Flanders, general passenger and ticket agent, Boston & Maine Railroad, Boston, Mass. The complete set of six portfolios of views on this line may be had for 36 cents. They are kept upon the library table at the home of the writer of this notice and are thoroughly worthy of such a place because of their beauty and their suggestiveness of the benefits to be had by busy men in outings in God's open air in New England.

Horizontal Boring, Drilling and Milling Machines.—The machine tools of this type made by the Niles Tool Works, Bement-Miles Works and the Pratt & Whitney Works are attractively presented in a beautiful catalogue recently issued by the Niles-Bement-Pond Company, New York. The book is devoted to floor-plate tools of this class, designed for work too large to be handled on machines of other types. It is profusely illustrated, and the descriptions are supplemented at the rear of the book by illustrations of these machines at work. A variety of examples are shown where pieces of odd shapes, and awkward to handle, are being drilled, faced, milled, etc., all at one setting of the casting. This is a work of value, and will be of interest to users of large tools.

Portable Tools for Railway Shops.—A new catalogue issued by H. B. Underwood & Co., 1025 Hamilton street, Philadelphia, presents illustrated descriptions of a line of special machinery which has become indispensable in railroad shops. This department is under the direct supervision of Mr. D. W. Pedrick, formerly of the Pedrick & Ayer Company, who has spent many years in designing and building these tools. The pamphlet describes portable cylinder boring bars, special boring bars for compound locomotives, Corliss valve seat boring bars, boring bars for lathe work, portable facing arms, attachments for taper boring, rotary valve seat planing machines, portable milling, crank pin turning machines and a radius planer attachment for planing links and circular work on ordinary planers. The plant of the company is the L. B. Flanders Machine Works, established in 1870.

Specialties in Car Shop Machinery.—A new catalogue of woodworking machinery, built with special reference to the requirements of railroad car shops, has been issued by the S. A. Woods Machine Company of South Boston, Mass. It is not offered as a complete reference book, but is intended to acquaint car builders with the latest productions of this company. The pamphlet describes a number of the latest developments of well-known types of machinery for car shops, for both heavy and light work. It also includes specialties, such as pneumatic pulleys, cutter caps, adjustable knife setting gages and self-oiling pulleys, and illustrates a direct motor connection, as applied to a Woods heavy car sill planer or timber dresser. This company is prepared to furnish any of its machines arranged for motor driving. This method eliminates all line shafting, belts and pulleys, and saves a large loss of power from these. The catalogue is well arranged and shows the work of one who understands the needs of modern railroad shops.

EQUIPMENT AND MANUFACTURING NOTES.

The Pressed Steel Car Company has removed its general offices in Pittsburg from the Tradesmen's Building to far more commodious quarters, occupying an entire floor in the Farmers' Bank Building, the step having become necessary because of the large increase in business.

A contract for the largest interlocking installation ever placed in this country, and probably much the largest in the world, has recently been given to the Union Switch & Signal Company for the St. Louis Terminal. The Westinghouse electro-pneumatic system will be adopted, and the contract calls for 258 working levers, with 51 spare levers, which will perform 748 functions.

The American Blower Company, of Detroit, Mich., are furnishing the heating apparatus for the new roundhouse of the Canadian Pacific Railway at Ft. William. This company has found it necessary to open two additional offices in the East. One is at 615 Hale Building, Philadelphia, under charge of Mr. Benjamin Adams, and the other is in the Frick Building, Pittsburgh, in charge of Mr. H. P. Curtiss.

H. B. Underwood & Co., Philadelphia, Pa., recently built a portable crankpin turning machine large enough to turn off pins while in position up to 15 ins. in diameter by 15 ins. in length. This is probably the largest portable crankpin turning machine ever built. It was made on the same general lines as the regular portable crankpin turning machine, for the manufacture of which this company is well known.

The American Steam Gauge and Valve Manufacturing Company, Boston, Mass., and the Mowry & Phillips Company have become merged under the corporate name of the first mentioned concern, a corporation organized under the laws of New Jersey. The officers are as follows: John McCandlish, president; M. Briggs Phillips, vice-president; J. L. Weeks, treasurer and general manager; R. B. Phillips, secretary.

The Columbus Steel Rolling Shutter Company, Columbus, Ohio, have received orders for their rolling shutter equipment from the Hocking Valley and Nashville, Chattanooga & St. Louis railroads. Messrs. Flaherty & Co., warehouse, Dayton, Ohio; Lane & Bodley, Dayton, Ohio; Frederick Jaeger, warehouse, Columbus, Ohio; W. Tomlinson, architect, Chicago, Ill., and C. D. Finley, for the warehouse of the Mutual Realty Company, of St. Louis, Mo. Their business is rapidly increasing.

The Commonwealth Railway Supply Company, Chicago, Ill., has recently been formed, with offices in the Monadnock block, to handle railroad mechanical supplies. Mr. E. B. Pickhardt, who is well known for his wide experience in the railway supply business, is president of the company. The firm will handle rolled steel and malleable iron tie plates, merchant iron and structural shapes, S and M brake shoes, the Hayward digging machinery, Western fir ties, the National fireproof paints, etc.

The Chicago Pneumatic Tool Company has sent us a copy of a telegram from their patent counsel in New York affirming the injunction previously granted against the Philadelphia Pneumatic Tool Company and sustaining the claims of the Chicago company for infringement of their patents. We quote as follows: "A point of special importance to the users of pneumatic tools is that this opinion of the Circuit Court of Appeals establishes the Chicago company's right to an injunction against all users of the Philadelphia company's infringing tools."

The rapid encroachment of the gas engine upon the hitherto exclusive field of its competitor, the steam engine, is well illustrated in the installation now operating in the plants of the Riter-Conley Manufacturing Company at Allegheny and Leetsdale, Pa., aggregating 1,600 h.p. in Westinghouse gas engines of the vertical single-acting type. Three of the engines are 28 h. p., and are direct-connected to polyphase generators arranged for parallel operation. These generators supply current for light and power in the new shops at Leetsdale. The remaining engines are employed for driving air compressors, pumps, etc. The gas engine is relied upon at both works for the entire power supply.

Messrs. G. S. Wood & Co., Chicago, manufacturers of the "Acme" Car Vestibule diaphragm, have opened an Eastern office at 39 Cortlandt street, New York in charge of Mr. Fred F. Bennett, general Eastern sales agent. Mr. Bennett is well known in railroad circles not only through his connection with this company, but by reason of his long connection with the railroad press, the American Steel Casting Company and the Chicago Pneumatic Tool Company. These diaphragms have come into very general use, as they are claimed to be much more durable than those made of rubber, while costing half as much. Samples and all information may be had and samples seen at above address.

The Chicago Pneumatic Tool Company announces a very satisfactory condition of business and tendencies toward a greatly increasing demand for their products. Various recent developments in the pneumatic tool industry are increasing the prosperity of the company. Among these is the successful issue of recent patent litigation against competitors for patent infringement. One of the most noticeable results is an increase in exclusive contracts recently secured, whereby this company will furnish the entire pneumatic tool equipment for certain concerns and railroads for certain periods of time. A number of such contracts have recently been signed, among them being one with the American Car Foundry Company. Some of these contracts were held up pending the decision of the infringement suit referred to. A long list of firms and railroads has been received, indicating recent large scale purchases of pneumatic machinery.

A NEW MULTIPLE-SPINDLE DRILLING MACHINE.

FOR DRILLING MUD RINGS FOR LOCOMOTIVES.

PRENTICE BROS. COMPANY.

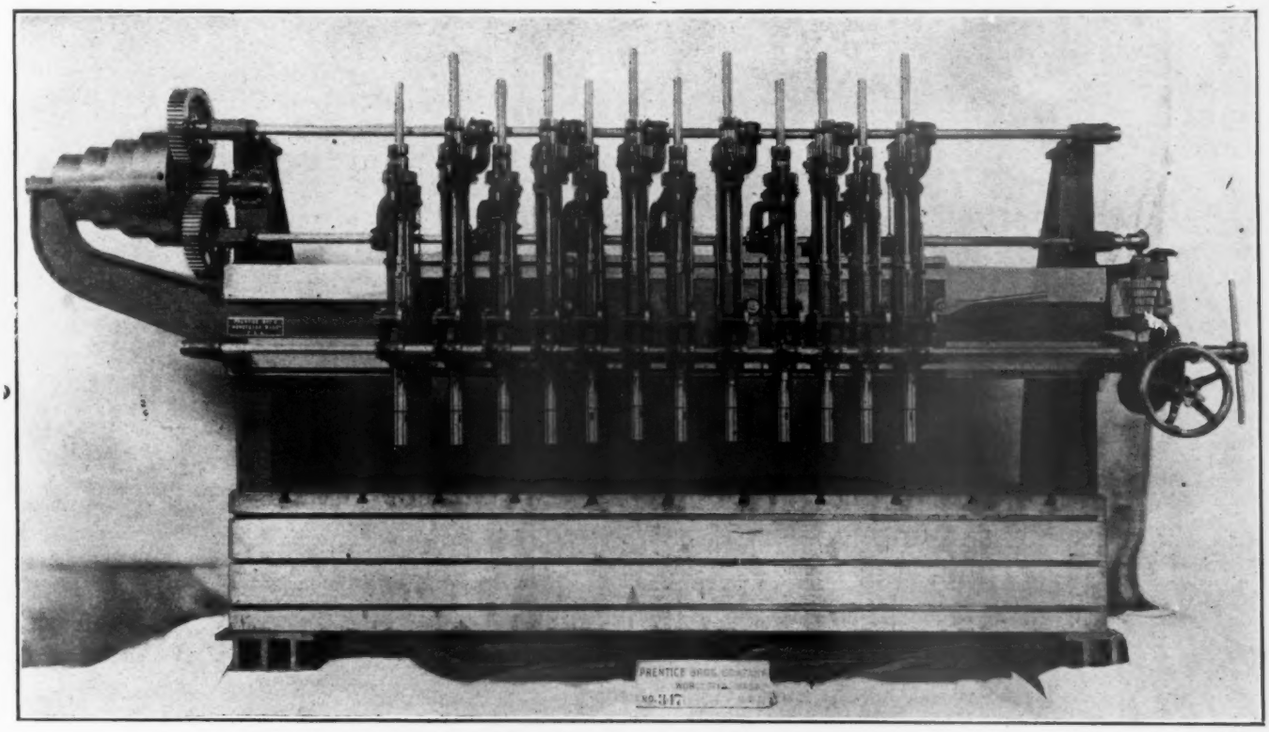
The accompanying engraving is an illustration of a new 12-spindle drilling machine for drilling mud rings that has recently been built for the American Locomotive Company by Prentice Bros. Company, Worcester, Mass. It embodies a new design and several points of interest.

The spindle heads are mounted, three each, upon four independent saddles spanning the cross rail of the machine. The heads upon each saddle are each adjustable thereupon by a rack and pinion to vary the distances between drilling spindles, and also each saddle has an independent lateral traverse upon the cross rail by a rack and pinion and ratchet lever. The four saddles may also be coupled up together, so as to constitute a continuous surface upon which the spindle heads may be adjusted to drill holes in a line on equi-distant centers. When coupled the saddles all have a universal traverse.

Each drill spindle has the independent quick approach and return movement, for which the Prentice Bros. Company's drills are so well known, and has also a stop motion by which it can be set to drill automatically to any depth and then release. The spindles are universally driven, through clutches for disengaging any one, and have four changes of driving speed and four feed changes. The spindles are raised and lowered collectively by a lever and the feed thrown in, or changed, all from the end of the machine.

SPECIFICATIONS OF PRENTICE BROS.' MUD RING DRILL:

Minimum distance between spindles	5 ins.
Maximum distance between spindles	8 ins.
Maximum distance betwen outside spindles	134 ins.
Traverse of spindles	14 ins.
Maximum distance, spindles to table	16 ins.
Distance between housings	112 ins.
Distance from floor to top of table	30 ins.
Diameter of spindles in bearings	2¼ ins.
Floor space	212 ins. x 60 ins.
Weight	18,500 lbs.
Capacity	Twelve 1-inch holes in steel



NEW 12-SPINDLE MUD RING DRILLING MACHINE.

PRENTICE BROS. COMPANY.

THE SAFEST PLACE IN A TRAIN.

Under certain circumstances the safest place for a passenger is in the firebox of the locomotive. But the circumstances are important. A locomotive was being hauled in a freight train from the builders' works to be delivered to a Western road, and, as is customary, it was in charge of a messenger. As there was no Pullman sleeper on that freight train, the messenger, according to his habit, rolled himself up in his blanket and bunked in the firebox of his charge, with the grate-bars for a mattress and his boots for a pillow. One night something happened. The train was ditched and his bedroom rolled over, down a high hill and into the valley. Those who saw it said that he crawled out of the fire-door rubbing his eyes and asking why the train stopped so suddenly. Our friend declares that he will never again ride in anything but his bomb-proof stateroom.

Tests of mechanical stokers recorded in a recent issue of *Engineering News* leads a writer in that journal to remark that "it seems that the economy claimed for mechanical stokers in every-day operation is at least open to question. It is certain that before deciding to install any particular one, the purchaser should know just what fuel he wants to use, what its peculiarities are, and how it is likely to act in the furnace under consideration. If too poor in quality it may be impossible to burn it on a chain grate, while if the ash fuses and clinkers badly it may be totally unadapted to other types." The chief difficulty in the tests referred to was the formation of clinkers, which are very difficult to handle in connection with automatic stokers. With coal which clinkers badly it may be actually cheaper to waste a portion in unconsumed state in the ash rather than attempt to burn it all with a high furnace temperature.

Among the passengers on board the White Star liner Celtic recently was a party of officials of the Lancashire & Yorkshire Railway. The party consists of Mr. J. T. Tatlow, locomotive department manager; Mr. G. Banks, freight traffic superintendent; Mr. John Wharton, freight traffic manager, and Mr. F. Dale, chief accountant. The object of their visit is to study the railway situation in the United States. They will spend several weeks on this side, at present stopping at the Waldorf-Astoria.

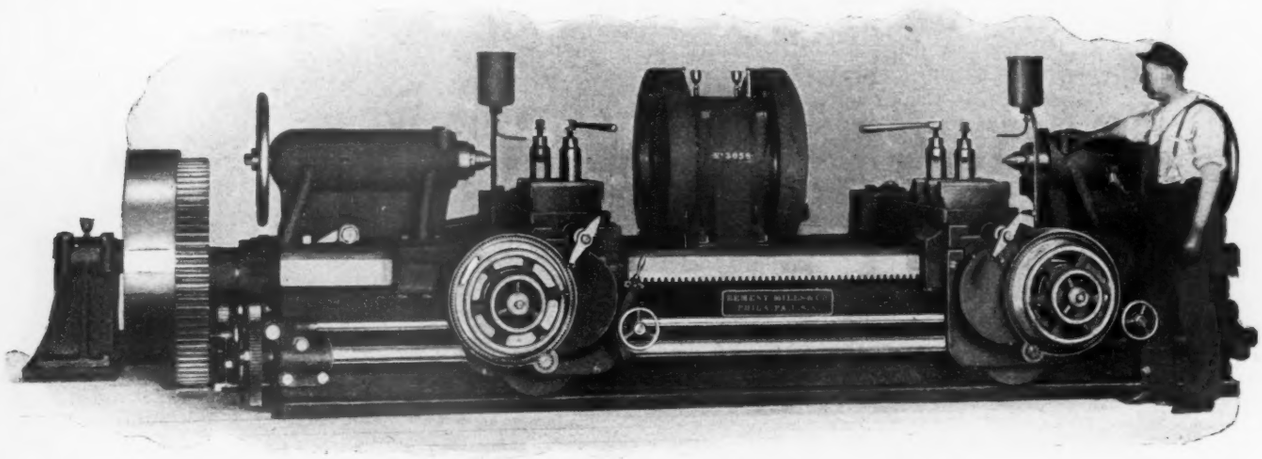
AN EXTRA HEAVY AXLE LATHE.

BEMENT, MILES & CO.

The accompanying engraving presents a view of an extra heavy axle lathe which was recently furnished to the Howard Axle Company by the Bement-Miles works of the Niles-Bement-Pond Company, New York. This is an axle lathe of the central-drive type and embraces the very heaviest construction, it having been specially designed for extremely heavy cutting with the high-grade air-hardening tool steels.

It will swing 15 ins. over the carriage, 8 ft. 4 ins. between centers. The revolving head has 12-in. hole through the center and is driven by two large spur gears (encased) engaging with pinions on the shaft in the bed. One side of the head carries a steel-faced driver, arranged to equalize the thrust on each end of the carrier dog. The carriages are very heavy and strong and are automatically fed by friction discs, the amount being variable while machine is running.

The machine is run at one speed only, that being close to the limit set by the cutting tools. The heavy duty obtained from this machine may be understood when it is known that the driving pulley is 42 ins. in diameter and is driven by a 10-in. belt, the driven speed being 360 rev. per min. The power required to drive it is upwards of 60-h. p. As may be seen, four cutting tools are used, all cutting at the same time.



A VERY HEAVY BEMENT-MILES AXLE LATHE FOR THE HOWARD AXLE COMPANY.

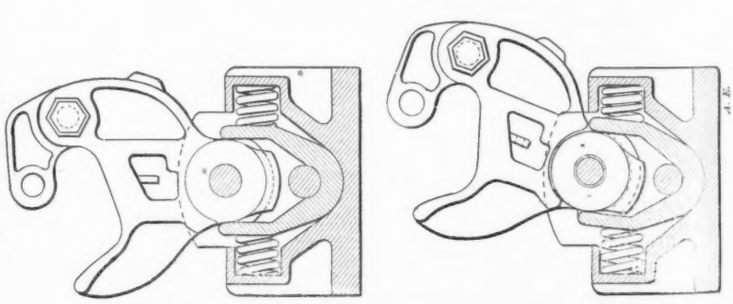
Mr. A. M. Baird has recently been appointed to represent the Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, in Topeka, Kan., and vicinity. Mr. Baird was formerly boilermaker at the Atchison, Topeka & Santa Fe Railway shops at Topeka, and has also been in the employ of several of the leading western railroads in the capacity of foreman boilermaker. He is the inventor of several compressed air tools, among them the well-known Baird staybolt nipper.

The Allis-Chalmers Company inform us that at the last meeting of the board of directors, held in New York, April 15, the regular quarterly dividend of 1¾ per cent. was declared on preferred stock. They also state that the volume of business on the books of the company to-day far exceeds that of any time since the organization of the company, notwithstanding the fact that the output of the plants has been increased to a large extent. There seems to be an unlimited demand for all kinds of high grade machinery, which is certainly a good indication that the prosperity is enjoyed in all lines of manufacture.

Messrs. George G. Frelinghuysen and Frederick T. Fearey, representing the Continuous Rail Joint Company of America, have concluded the purchase of about twenty acres of land at Troy, N. Y., with the rolling mills, machine shops and numerous other buildings formerly owned by the Troy Steel Company, part of which they have been operating under lease for the past three years. The property has a dock frontage on the Hudson River and the New York Central Railroad runs through it. A new side-track has just been completed from the New York Central Company's tracks around the rolling mill. The Wynantskill Brook runs across the entire plot, giving an excellent and constant supply of fresh water. The plant will hereafter be known as the Albany Iron and Steel Works Department, of the Continuous Rail Joint Company of America. The output of the products of the company will be greatly increased. It is well known through railroad circles that the Continuous Rail Joints are universally liked and that 15,000 miles of railroad track have been equipped with this appliance. The general offices have always been and will remain in Newark, N. J.

WASHBURN DOUBLE-MOVEMENT TENDER AND PILOT COUPLER.

A new coupler for tenders and the pilots of locomotives has been developed by the Washburn Coupler Company of Minneapolis, Minn. It is specially designed for switching locomotives and resembles in its general features the well-known flexible head pilot coupler of this company. It has the side movement of the draw-bar and also a movement of the head in the bar, thereby giving a large amount of play to the head of the coupler. It is said to provide greater movement than any other device of the kind on the market. The material is cast steel, except the pins. It is heavy and very strong. In coupling on ordinary curves the head will turn far enough to couple without difficulty and in cases of extraordinary curvature the intermediate bar swings far enough to one side to allow the couplings to come together. Upon passing again to the straight track the springs center the immediate bar to its normal position.



THE WASHBURN TENDER AND PILOT COUPLER.

The manufacturers desire to direct attention to the fact that there are other devices for this purpose upon the market which are infringing upon their patents.